CHIROPRACTIC SPINOGRAPHY

THOMPSON

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SPINOGRAPHY

VOL. X
THOMPSON
1921

TEXT

ON

Chiropractic Spinography

BY

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THIRD EDITION
1921

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CONTENTS

Part VI

Part VII

PREFACE

Chiropractic is a progressive science and as is true of all progressive movements, it employs the progressive ideas which will add to its effectiveness. Early in its development Dr. Palmer realized the necessity of, in some manner, determining conditions of the spine which could not be sensed by palpation. Certain conditions occasionally prevail which baffle even the most skilled palpator and it is in these cases that the employment of the X-Ray, as a verifier of the Chiropractor's findings, should be utilized. Perhaps there is no one who has had the opportunity to become more proficient in the art of palpation than Dr. Palmer himself and yet he refers to the X-Ray operator many cases. This is merely mentioned to show the value of spinography even to the expert, and proves conclusively the necessity of it to the practitioner who does not have these advantages.

With the realization of this fact in view, the science of Spinography has been developed and this book has been written, not to deal with the various phases of Roentgenology, but with that particular branch which applies to the study of the spinal segments and their juxtaposition.

At this time, I wish to acknowledge the valuable and kindly suggestions of Dr. B. J. Palmer, in preparing this work; to thank Mr. F. J. Farrelly for permission to use his valuable and instructive paper on the "Physical Properties of the X-Ray"; also to thank Mr. Wm. F. Meyer for supplying cuts, and his assistance in preparing definitions. I personally wish to thank Mr. G. M. Ellis for the idea of preparing this work and for the many suggestions he has given me pertaining to X-Ray Technic. I am very grate-

ful to my friend, Dr. J. W. Healey, who has corrected and submitted the work on electrical terms and apparatus, and to my friends and co-workers, Drs. Clyde C. Hall, Harry E. Vedder, Walter F. Lotz, Ray Richardson and Mr. P. A. Reimer, for the valuable assistance and co-operation in compiling this work. I am also indebted to Carl V. S. Patterson and Frederick W. Reuter of the Patterson Screen Co. for the instructive article on the intensifying screen. I also wish to thank Mr. J. H. Clough of the General Electric Company for the valuable work on the Coolidge tube and supplying cuts for same. I wish to thank Mr. Geo. W. Brady for his many courtesies and valuable suggestions.

ERNEST A. THOMPSON.

Figure 1—Another Corner of the P. S. C. Spinographic Laboratory with a Class of Plate Reading in Session.

INTRODUCTION

DEVELOPMENT OF SPINOGRAPHY AND ITS VALUE

As to the discovery of X-Ray work I am not conversant except in a general way. As to mechanical details, I possibly know less.

The history of the X-Ray was a struggle of many ups and downs. In its experimental stage I watched the work with interest and let the other fellow have his grief. Also, I made yearly trips to Chicago to the electrical show and watched the progress of the X-Ray work, always hoping that some day a machine would be made which could and would penetrate the body to make pictures of spinal columns. Nowadays it seems impossible that once upon a time this could not be done. I visited the factories which made X-Ray machines, telling them of my hopes and desires.

Finally the machine I wanted appeared. I immediately ordered one shipped to The P. S. C. We fitted up a laboratory and began work. For two years we made as many plates as time and finance permitted daily. We never made a charge. Were we not merely doing our share of the experimental work even upon spines? At the end of two years we began to charge $1 per plate. It was five years before we charged $2 per plate. All this free and low rate work, notwithstanding the lowest priced plate that could be purchased in some X-Ray laboratories, was $25 for even a wrist.

It was during these experimental years that we went through the starvation scientific period. We developed the

technic that is today known as P. S. C. Spinography—taught here from then until now. It started here, radiated from here and comes back to us tenfold, with many lives saved.

We introduced the X-Ray into spine work back in 1910. We were the first people in the world to do so. Up until that period internal visual spine work was practically an unknown quantity. The living human spine was as the shores of Africa were before Livingston or Stanley had set foot upon them. Many times in our earlier years our spine plates were exhibited at the different "regular" medical conventions, without name and address, of course. Many were the compliments passed upon that work done in deeper tissues, especially of the spine.

The X-Ray was originally used by physicians, pathologists and diagnosticians to ascertain the location and condition of pathology, the position of traumatic conditions, the location of foreign substances, and, experimentally, it was being tried as a cure-all for diseases, more particularly for cancer.

The original Chiropractic purpose was not to use the X-Ray for therapeutic purposes, to ascertain normal or abnormal tissues, the character of fractures or whether there was renal calculi or a bullet in the body. We had already settled how a cure occurred; we did not care much about pathological plates; we did not deal with fractures or dislocations; and if there was a bullet or any other foreign substance, that was a case for a physician or surgeon, not for a Chiropractor. We knew our place and proceeded to strengthen our position accordingly.

Chiropractic had long maintained, even at this early period, that a vertebral subluxation produced pressure upon nerves which interfered with the normal and free transmissions of mental impulses between the brain and its body; that this unequal state of balance between generation, transmission and expression produced disease; that that summum bonum of all life and death, health or disease issues pivoted around a study of the correct or incorrect position of vertebrae.

Therefore, the Chiropractor palpated the spine, found irregular bumps which we called vertebral subluxations (since they were something short of a dislocation or fracture), "adjusted" the subluxation, reduced its position to normal, and the patient got well.

Physicians, who ought to know, denied any of our realities. If a subluxation could exist they would have found it "long ago." Vertebral subluxations could not be without fracture or dislocation, in which event the patient would be dead.

When we saw the bump, the physician showed us bumps on knuckles—"Does that prove subluxation thereof?"

Under adjustment the vertebrae moved; so did he work his joints—"Does that prove subluxation thereof?"

We heard the vertebrae crack when adjusted; he pulled his fingers and they cracked—did that prove anything?

We said that the patients felt them move; this he claimed was psychological—they just thought so.

All we offered him was "theory and art"; what we thought and what the patient thought; what we said we felt or saw, and what the patient said he felt in the back and with his disease. This he said did not prove any of our contentions. He offered scientific and laboratorical proofs why this could not be so. He could scientifically reason us out of our Chiropractic house and home. We were, plainly speaking, "buffaloed."

Inasmuch as everything we did, what we went after or secured, our statements and logical facts, that patients' pains and reliefs revolved about that vertebral subluxation, could be scientifically denied, it was up to us to prove with that same degree of scientific proof that vertebral subluxation did exist.

The advent of the X-Ray into Chiropractic was to prove that vertebral subluxations did actually exist and could, by use of the X-Ray, be made visible to the eye.

Physician after physician would stand aghast at the actual clinical changes taking place in case after case, as a result of vertebral adjustment. They would stand amazed at the disappearance of pathology which they knew was positive. They tested our cases before adjustment and were thoroughly satisfied that the patients had to die; they tested them after adjustment and found the patients well; but when it came to acknowledge that an adjustment of a vertebral subluxation was responsible for the results obtained they bucked and refused to credit it.

Once we had hurriedly perfected an early technic and begun taking hundreds of plates, the evidence was before them beyond all dispute. One by one they acknowl-

edged the fact, and then their attitude underwent a radical change from ridicule of our fundamental working principle to a serious consideration of it and of the philosophy which had to accompany that principle to be consistent with the results delivered.

Whereas once medical books said that a vertebral subluxation was impossible without a fracture or dislocation; whereas other books had said that two teams of "Percheron horses pulling against themselves could not budge one vertebra from the other, in the recent state," now almost every book acknowledges them as of common occurrence; in fact some books go so far as to state that almost everyone has them. Medical dictionaries, recognized as standard, now include in them our common nomenclature of "subluxations," "adjustment," "spinography," etc., most of these words being quoted from the writings of the author of this chapter in this book.

Having established this phase of our work, the X-Ray would have gone into the discard, but there was a more valuable use for it.

To prove the clinical hypothesis of a vertebral subluxation, we palpated with our fingers on the surface of the skin, found "a bump," established which direction it was in, proceeded with our work. We succeeded in many cases, failed in others. Why? Perhaps the position that we thought we felt was not correct. Suppose we take a picture and see exactly the conditions existing inside.

In proving the primary purpose, we found that in many cases what we thought existed under palpation was not so.

Reasons:

Palpation could be in error.
Judgment could be false.
Spinous processes could be bent.
Exostosis could exist and fool us.
Process tips could be hypertrophied.
Acromegaly and other conditions could bewilder us.

This necessitated some form of scientific work which would let the Chiropractor's eye look into and see exactly what existed. We wanted to know the position of the subluxated vertebra exactly as the surgeon would want to know the location of the bullet before he probed.

Cabot studied carefully 1,000 cases and made actual comparisons of diagnosis in the living and proved them by autopsy on the dead. He diagnosed them from the best means at his command. Working from the outside he named what he thought was inside and prescribed accordingly.

He palpated, ausculated, used stethoscope, felt the pulse, looked at the tongue, examined feces, urine, etc.

In 1,000 case comparisons he stated that as high as 85 per cent of some cases were wrong in diagnosis and that 50 per cent were wrong in the gross.

Why? Because he was trying from the outside to determine what was inside.

The Chiropractor took several thousand cases, made accurate and careful analyses of their vertebral subluxations and then compared them with the spinographic plates showing the exact facts of the living case, not waiting for an autopsy to be of benefit to the dead case.

As many spines as the author has palpated in 23 years, as varied as those spines have been, and as accurate as he aims to make his work, we tell you candidly that about 25 per cent of our analyses do not tally with the facts the spinograph reveals to our eye.

The Chiropractor palpates, makes analyses, from the surface, of the conditions he thinks are more deeply embedded. Dozens of points or combinations thereof might throw him entirely off, no matter how experienced he may be. We are thoroughly convinced from the comparison of over scores of thousands of spinographs that a percentage is bound to be wrong.

Why? Because we are trying from the outside to determine what is inside.

Cabot's diagnosis is as good as it can be; our analysis is as correct as we can make it. Neither Cabot's nor our honorable intention can be questioned. We have done the best we can with the means at our command.

Is it possible to eliminate this percentage of errors, be it large or small?

Is there some way by which we can know rather than hypothecate?

Yes.

As a result—the scientific art of spinography. No longer need we rely on theory or art. Science proves.

It has been said that "spinography" was but a newly coined word to express the ordinary X-Ray work on the spines; therefore, spinography. The word was especially coined by us, as Eastman coined "Kodak."

There are hundreds of X-Ray experts, but nowhere are they touching the characteristic P. S. C. spine work.

Anyone can be taught to operate an X-Ray machine in an hour or two. The manufacturer teaches the purchaser in two days.

It takes us exactly one month, six school days a week, to somewhat inculcate the principles of this work to the student; and, at that, all this instruction is Greek except to him who is first a Chiropractor, knows Chiropractic, and practices its work. Even in this time we can but lay the principles and teach the art, all of which must be practically applied to his practice after he leaves here for the field.

Today spinography is used to interpret spines which have not been palpated; to correct interpretations made by palpation; to learn why our palpation may have been at fault, in living people, in order that absolute readings may be determined beyond a shadow of doubt and the proper adjustment given with a perfect degree of assurance, with all elements of doubt entirely obliterated.

Spinography does more than to read subluxations—it proves the existence, location and degree of exostosis, ankylosis, artificial, abnormal shapes and forms, all of which may prevent the early correction to normal position

of the subluxation. It shows the Chiropractor why his patient could not get well and gives him information as to what to do, where and how to work, in order to restore early health to the case he would otherwise fail upon.

Spinographs are not photographs. A photograph is a graphic recording of that which is superficial to the object being pictured. A spinograph is a graphic recording of that which is deeply imbedded in the object being spinographed.

To make a photograph the surface lights and shadows must be thrown on the object. To make a spinograph the lights and shadows must be thrown through the object.

In a photograph that which is light and dark was light and dark on the object when photographed. In a spinograph the conditions are reversed; that which was solid will be light and that which was thin will be dark.

Spinographs then are but shadowgraphs. That which is solid, which intervenes between the light and the plate, will leave a light shadow, and vice versa.

Reading spinographs, then, is but study of shadows, high lights and middle tones.

Every human body has size, rotundity and depth. The emulsion on the plate is a flat tissue thickness, yet it records the shadows made by the entire body, regardless of thickness. Assume a body sixteen inches thick from the anterior to the posterior and the region being spinographed is the spine. The tube is placed above the abdomen, the plate beneath. The X-Ray passes from the tube to the plate, the shadows and lights being recorded. The patient was six-

teen inches thick when placed on the table; the graphic recordings are but a tissue. In reading this plate we must differentiate the depth of the shadow, thus placing its position. If it were possible to place three copper pennies, one on the umbilicus, one on the stomach and one on the spine of a vertebra, each at a different level, I could tell which was on top, all because of the different degree of lights recorded.

Thus are the different positions of vertebrae determined. The centrum, pedicles and spinous process tips are as flat as a tissue on the plate, yet were not so in the body.

Reading spinographs is an art or science, which should be cultivated, upon which too much experience cannot be had.

Your work primarily divides into three important divisions:

1st—Proper palpation.
2nd—Proper analysis.
3rd—Proper adjustment.

As the latter two depend on the former, it is necessary to start right in all events.

Case No. 1:
You palpate the spine.
Make an analysis.
Secure a record.
Adjust your case.
He gets well.

Your palpation was correct, or he could not get well.

Case No. 2:

You palpate the spine.
Make an analysis.
Secure a record.
Adjust your case.

Case gets worse, does not improve, or improves extremely slow.

You must conclude that your palpation was not correct or in line with the facts, which a well taken spinograph can readily prove.

To spinograph that case is to save failure with it.

You are poor, you are just starting, you cannot afford a spinograph outfit.

Your case is poor, the distance is too great from you to us—what can you do?

You can't do it. If you are poor, you can't buy; if your case is poor, he can't buy railroad tares.

If you are just starting and cannot afford an outfit, and your case is poor and cannot afford to come, send the case to some place where spinography has been properly studied; where this work is correctly done; where the price is within reach; where the tremendous overhead is assumed by others; where the work is so abundant that it is excellent; and where the spinographers cannot afford to do otherwise than do for you that which you cannot do for yourself.

Hundreds of Chiropractors have referred thousands of patients to us for spinographs during the past nine years.

Our average at present is between 150 and 200 Chiropractors per month, sending cases for which we make on an average of 300 to 400 exposures weekly.

Our own faculty members refer their doubtful cases to this department, which fact shows that we do not only teach the use of the spinograph, but use it.

Invariably, the report returns to us showing success where before it showed failure. The length of time taken to obtain results is cut down where before it was prolonged. Pain is decreased where before it was increased; and life is saved where before it was lost.

Success is based, Chiropractically, on results—first, last, and all the time.

Can you afford to lose a single case, either in death, failure or non-delivery of results?

Hundreds of Chiropractors, from Coast to Coast, Canada to Old Mexico, say "No." All the states in the Union and almost all the countries in the world have sent cases to our laboratory.

You have a case in Washington or Maine, Florida or California. Your patient needs a spinograph. Who pays the bill?

You desire that we hold consultation over the case, palpate the spine before and after spinographing, and send you a reading. Who pays the bill?

Perhaps the case is of such character that you ought to come with the patient. In such event, who pays the bill?

These are all accounts that must be paid by the patient. Railroad fare, spinograph costs, consultation charges and hotel expenses for himself and the Chiropractor—should he need to come—are paid by the patient.

Frequently the Chiropractor will gather six or eight patients, his expenses being divided pro rata.

The spinograph means the difference between failure and success:

No results and results.
Guess and knowledge.
Doubt and positiveness.
Theory and fact.

We extend to you, each and all, an invitation to visit our spinograph laboratories.

See the hundreds of plates on daily exhibit.
See the exposures made.
Study the plates and their value.

Then send your doubtful patients and make a larger success of your profession.

We take a pleasure in writing this introduction to this able and excellent work on Spinographic Technic. Dr. E. A. Thompson has been with us more years than any other teacher on this subject. He has unquestionably seen more work, read more plates, taught more students than any other man living, not excepting the author himself. It is because he is so eminently fitted for this peculiar line of

work that his work on this question becomes a paramount, valuable addition to the world's scientific publications. Judge not this work by its size, but by the actual, definite working knowledge it contains.

Chiropractically yours,

B. J. PALMER,

President, P. S. C.

Figure 2—Another Corner of The P. S. C. Spinograph Laboratory Showing Larger Display Cases

PART I

CHIROPRACTIC SPINOGRAPHY

The subject of Radiography is one which has occupied the attention of the scientific world for a number of years but only within the last few years has it reached the high degree of perfection which it now possesses. Never before have there been as many phases available for general use. Experiments and investigations have been carried on in many different directions, and because of this, the science of radiography has taken on a new aspect, both in the commercial world and in the professions. This has all been made possible because of many different minds, each working toward a certain end.

Among these the Spinographer holds a position of first rank. First, because he has perfected the work of radiography in its connection with the spine, and second, because of the far-reaching facts which this systematizing of knowledge has produced. Whereas, the medical profession has followed the use of the radiograph in a limited sense, the Chiropractor has broadened the field by showing its definite application to every disease to which the body is subject. It is by its use that the relative positions of the spinal segments are determined, and this is done with an accuracy which cannot be equaled through palpation.

Without doubt, the laboratory equipment in the Palmer School of Chiropractic is the most complete in the world for experimental and scientific investigation along the lines of Spinography. The author has been engaged in research and practical work for the past seven years,

devoting his entire time to this subject as a specialty. Without doubt, he is in a position occupied by no other as an authority on Spinography.

Much of his labor has led to results which added nothing of practical value to this particular branch of the science. On the other hand, much of it has been productive of results which are vital to every Chiropractor. It is the purpose in this book to correlate only those facts which are of practical value to the profession, omitting the great mass of material which is of no special use.

The following is a list of definitions, particularly applicable to this work, in which the student must be thoroughly grounded before he can gain an adequate knowledge of the subject:

DEFINITIONS AND TERMINOLOGY

1. Roentgen—pronounced rent-gen.

2. Roentgen Ray—A phenomenon in physics discovered by William Conrad Roentgen.

3. Roentgenology—The science of radiography, or the study and practice of the roentgen ray as it applies to the different branches of the healing art.

4. Roentgenologist—One skilled in roentgenology.

5. Roentgenogram—The shadow picture produced by the roentgen ray on a sensitized plate or film.

6. Roentgenograph—To make a roentgenogram.

7. Roentgenoscope—An apparatus for examination with the fluoroscopic screen, excited by the roentgen ray.

8. Roentgenoscopy—Examination by means of the roentgenoscope.

9. Roentgenography—The art of making roentgenograms.

10. Roentgenize—To apply the roentgen ray.

11. Roentgenization—The application of the roentgen ray.

12. Roentgenism—Outward effect of the roentgen ray.

13. Roentgen Diagnosis—Diagnosis by aid of the roentgen ray.

14. Roentgenotherapy—Treatment by the application of the roentgen ray.

15. Roentgen Dermatitis—Skin reaction due to too strong or too oft-repeated application of the roentgen ray.

16. Radiography—Roentgenology.

17. Radiograph—Roentgenogram.

18. Radiographer—One skilled in operating an X-Ray equipment.

19. Radiologist—One operating an X-Ray equipment.

20. Skiograph—Roentgenogram.

21. Fluoroscopy—Roentgenoscopy.

22. Stereoscopic Radiography—The taking of two exposures of the same region with the source of rays moved the average distance between the pupils of the eyes or two and three-eights inches.

23. Spinography—Coined by Dr. B. J. Palmer, indicating the science of radiography as applied to the spine only.

24. Photography—The science of taking pictures of the visible and the art or process of procuring pictures by the action of light on certain substances sensitized by various chemical processes.

25. X-Rays—So named because it is an unknown quantity.

26. Ampere—The commercial unit of electrical current flow.

27. Milliampere—The unit of electrical current flow in an X-Ray tube.

28. Volt—The commercial unit of electrical pressure causing current to flow.

29. Kilo Volt—One thousand volts.

30. Transformer—For transforming a current of one voltage to another.

31. Direct Current—Flowing in one direction without periodic variation.

32. Alternating Current—Subject to periodic reversal called "frequency."

33. Converter—For changing direct to alternating current.

34. Motor Generator—For changing alternating current to direct current.

35. Synchronous Motor—A motor, the rotary of which operates in step or synchronism with the alternating current used to excite it.

36. High Tension Rectifier—Usually in form of a disc with metallic segments for commuting the high tension alternating current of the step-up transformer into a pulsating-uni-directional current desirable for exciting the X-Ray tube.

37. X-Ray Tube—A glass bulb or globe exhausted to a high vacuum and provided with specific metallic electrodes within, designed to promote the electrical current flow in one direction when a high tension current is impressed upon the outside terminals of the electrodes, thus generating the X-Rays within.

38. Back-up Spark—When a current of high voltage is impressed upon the terminals of an X-Ray tube, the vacuum within will resist the passage of this current until the voltage or pressure is raised sufficiently to pass through the tube. The critical point where this occurs may be measured on a parallel spark gap and read off in inches and is called the back-up spark.

DISCOVERY OF X-RAYS

The discovery of X-Rays dates back to April, 1895, and was made by Professor Roentgen, the same year that Chiropractic was discovered. The first paper on the subject was read at the Wurzburg Physico-Medical Society on December 28, 1895. The discovery then really dates back to the Crookes vacuum tube.

Although it is a fact that Roentgen was led to his discovery by Lenard and others, who were at the time experimenting with the Crookes vacuum tube (in this connection we might state that Lenard as well as Stokes and Roentgen were led to a certain point by Crookes), nevertheless all former experimenters failed to see in their ex perimentation what Prof. Roentgen saw when he, as well as others, noted that the vacuum tube they were using had the power of causing fluorescence on a fluorescent screen. When Prof. Roentgen was asked, "What do you think about it?" he stated, "I will investigate." This he did and his investigation was so thorough that the fundamental principles of the X-Ray have never been changed. Although there have been vast changes in the apparatus in the way of improvements in capacity, there has been no change in the fundamental rules laid down by Prof. Roentgen.

The actual discovery was accidental, like many other great discoveries in science. During the search for invisible light rays, Roentgen turned on a low pressure discharge tube, which was completely covered with dark paper that would exclude all ordinary light. A fluorescent screen was lying on a table near by when the discharge tube was turned on and the screen became fluorescent. This experiment was followed by others in which Roentgen became convinced that they were new and penetrative rays which he promptly designated as X-Rays and the name still obtains.

In this simple way one of the most important discoveries was made in physics; one in which time has brought forth many improvements in the apparatus used to furnish

current for the X-Rays, but no change in the laws which govern them.

Lenard missed priority over Roentgen by a very slight margin, as he had discovered the fact that the new light (X-Ray) would penetrate through an aluminum sheet and show light on the table below, but he had failed to follow up the lead and find out what the new ray really was able to do. It was Roentgen who established the facts in connection therewith.

PHYSICAL PROPERTIES OF X-RAYS

Some writers claim that X-Rays are particles somewhat like electrons, but this theory has few supporters. It can be stated in a few words that X-Rays are waves of ether set up when a cathode stream traveling at a tremendous speed is suddenly stopped. These waves travel in straight lines and cannot be bent by the strongest magnet and are neither negative nor positive.

Penetration can be explained as being dependent upon the length of the generated ray or ether wave. The wave length of X-Ray determines its penetrative power. X-Rays like light have wave length and the shorter the wave lengths the more penetrative are their qualities.

The wave length of light has a fixed measurement but with X-Rays it is different. The wave length of X-Rays varies from a very short wave length to a long one. The short wave length represents deeper penetration and naturally the longer ones are less penetrative.

The production of X-Rays is not continuous the same as light, but they are generated at irregular intervals.

The property of X-Rays to penetrate opaque substances is due to the fact that the waves are irregular in length and do not set up vibration on the surface struck.

Glass is transparent to light because it is not thrown into vibration by light.

A thin sheet of metal is opaque to light because the light waves, falling upon it, produce vibration within the metal.

The speed of X-Rays is the same as light; that is they travel at the rate of 188,000 miles per second. The different wave lengths all travel at this speed.

In order to produce a picture of the head or hips when using a coil, the vacuum must be very high for the rays to penetrate to the dry plate. This condition is explained by the fact that the voltage from a coil is fairly uniform and it imparts a certain speed to the cathode stream when the vacuum is high. A high vacuum means the absence of gas and as before stated, in a high vacuum tube the cathode stream attains a great speed and very highly penetrative X-Rays are generated.

Penetration is determined by voltage and tube resistance, but quantity of X-Rays is represented by milli-amperage. A ray can possess a certain penetrative power, but it might not be able to fog a dry plate unless backed up with quantity due to milli-amperage.

Induction coils can generate penetrative X-Rays, but in a great many instances the ray so produced lacks quantity, therefore it requires a longer time to take a pic-

ture as compared to the time required when a transformer supplies the energy.

Deep penetrative rays can be produced by an X-Ray tube from a transformer, owing to the fact that the voltage can be varied from high to low. If the vacuum in a tube is low, and high voltage is passed through it, the voltage overcomes the resistance of the tube and compels the cathode stream to travel at a high speed producing rays of fairly high penetration. If a high voltage is passed into a tube in which the vacuum is high, the cathode stream reaches its maximum speed and consequently, for a short period a large quantity of highly penetrative rays is generated. If a low voltage is used to perform a certain function and the vacuum is low also, then X-Rays of low penetrative qualities are generated and time becomes the principal factor of exposing.

These varying conditions can be understood when we realize that at the time a tube is working at its maximum point, the speed of the cathode stream is about 90,000 miles per second.

When a gas tube generates X-Rays below its maximum value, the cathode stream travels at a lower rate, producing a less quantity for the same time. This because in a gas tube the large amount of gas present impedes the cathode stream and a large number of electrons from the stream are absorbed by the ions before reaching the anode. When the speed of the stream is rapid, all of the electrons reach the anode without combining with the ions. The variation of resistance in a Coolidge tube does not change the quantity of X-Rays produced so long as imput of current or milliamperage remains constant.

It is sometimes difficult to understand why at one time a certain picture is taken in say one-half second, and why again it requires two or three seconds to produce the same result on the same region. This is due to the fact that a different penetration is used.

It is on this principle that time is an essential factor, and as utilization is made of a low penetrative quality of X-Rays, the length of exposure becomes greater in order to produce the same quality of picture produced in a shorter length of time by a more penetrative ray.

Very frequently some Roentgenologists compare the X-Rays to alpha and beta rays of radium; some even go further and say that these two rays are generated in an X-Ray tube.

Such statements are very misleading because X-Rays cannot be compared to them. The gamma rays of radium are like X-Rays.

The Alpha rays of radium are very weak, and possess little or no penetrative power; they are absorbed by a single sheet of ordinary writing paper or four inches of air. They are positive atoms of electricity after they leave the mass of radium and then transmute into helium gas.

Physicians using radium for treatment purposes usually filter out the alpha rays because they are dangerous to the skin.

The beta rays are particles or electrons thrown off from the radium at a rate of 100,000 to 150,000 miles per second and are more penetrative than the alpha rays but not as greatly penetrative as are X-Rays. Beta rays are

absolutely the same as the electrons in the cathode stream and possess all the same physical properties except as to speed.

The Gamma rays are analogous to X-Rays in all except penetration. The strongest X-Rays are stopped by a sheet of lead three-sixteenths of an inch thick, while gamma rays will pass through a solid piece of lead six inches thick. The Gamma rays are supposed to be waves of ether set up by the impact of beta rays passing through the atmosphere in the same way that X-Rays are produced when a cathode stream is suddenly stopped.

X-Rays cannot be deviated by a magnet, neither can the gamma rays. They both travel in straight lines and do not correspond to either a negative or a positive test.

Secondary radiations are a great source of trouble to all radiographers, and it is impossible to eliminate them, no matter what means are employed. When X-Rays strike a body it immediately becomes radioactive—that is, the body emits secondary rays or "S" rays, so called after Sagnar, who was the first to detect them. Secondary radiations are not like X-Rays nor do they possess the same penetrative power; they are nothing else then electrons liberated from any body that the X-Rays strike and do not penetrate.

Secondary rays are the same as the electrons in the cathode stream and the beta rays of radium. The penetration of secondary rays and the number generated varies depending upon the substance that the X-Rays strike.

When X-Rays strike a sheet of aluminum the liberated secondary rays are more penetrative than if they strike a

sheet of lead. When they strike the former only a small amount of secondary rays are produced, but they penetrate fairly deep, while with the latter they possess little or no penetrative power, but are liberated in large quantities.

The reason that secondary rays cannot be entirely eliminated is because they are generated in the air when X-Rays pass through it, also when the rays strike the patient and as they pass through the patient.. They are produced as well when X-Rays strike the envelope, radiographic plate, and the table or floor below.

It has been found that X-Rays can be deflected the same as ordinarily light. This is done by passing a beam of X-Rays through a crystal of zinc sulphide, the rays bending at right angles.

A later theory has been advanced by Rutherford in which he regards an atom as built up of a minute nucleus of positive electricity surrounded by a cluster of electrons which rotate round the nucleus, and an outer group of electrons which also rotate and are less rigidly attached. The outer electrons, by their number and arrangement, are responsible for the chemical and physical properties of the atom; the inner electrons have influence only on the phenomena of radioactivity. This explains why physical and chemical behavior do not go hand in hand with X-Ray and gamma ray phenomena.

PHYSICS OF X-RAY PRODUCTION IN GAS TUBES

Almost all of the literature published on X-Rays deals with the use of the same for producing radiographs, fluoroscopic examinations and treatment. Very little is published

on their physical properties. The object of this paper is to give insight as to how X-Rays are produced by the passage of high voltage current through a vacuum.

Since the discovery of X-Rays and radium, the physicists have found that there is a mass of matter smaller than the atom and this is known as an electron or corpuscle, different writers using either name. In this paper the word "electron" will be used throughout.

An electron is the smallest particle of matter and is negative electricity. In fact, it is a solid mass moving through space and in a vacuum at different speeds. The size of an electron is approximately one thousandth as great as an atom of hydrogen gas. All atoms, regardless of the different properties they possess, are composed of electrons.

An element, liquid, solid or gas is a substance composed entirely of atoms of the same kind. The latest tables show that there are about eighty-eight elements and all these are composed of electrons.

The reason that elements possess different properties is because their atoms possess different numbers of electrons. No two elements possess the same properties or will answer to the same set of tests. The property of the element lead is different from that of iron, and gold is different from tin, yet they are all fundamentally made of the same material.

This is accounted for by the actual number of electrons that go to make each atom. For example: hydrogen is the lightest known gas, and the atom of this gas is one thou-

sand times heavier than an electron; in other words, every hydrogen atom contains one thousand electrons.

If we could collect one thousand electrons without regard from where they came, and could compel them to unite in one mass of a definite size, we would be making an atom of hydrogen gas. The same applies to oxygen; this gas containing sixteen thousand electrons to an atom; nitrogen contains 14,000; mercury 200,000. In order to estimate the number of electrons to an atom, muitiply the atomic weight of the atom by one thousand. As all atoms are of the same size, but of different weights, it is readily understood why they possess different chemical and physical properties.

It has been stated that every electron is a solid mass of negative electricity, and that these electrons go to make an atom, so naturally we would think that a mass of electrons, being negative would be forever repulsing each other and could not exist in such a small space as in an atom.

Professor J. J. Thompson has worked out a theory that the electrons in an atom arrange themselves at a certain distance apart so that they will be in equilibrium under the attraction of the external shell of the atom and their own mutual repulsion. In order to illustrate this on a small scale, say that there are only two electrons to an atom, they will arrange themselves like A and B in figure 3. In this case they will be in equilibrium if placed on opposite sides of the center of the atom at a distance from the center equal to half the radius.

If there are three electrons, A B and C, they will be in equilibrium if they form an equilateral triangle with its center at the center of the atom.

Four electrons will arrange themselves at the corners of a square, five will form a square with one in the center. As the number of electrons to the atom increases, they will arrange themselves in a number of concentric rings, the outer rings containing the largest number which decreases toward the center.

Electrons are not always bound up in the atom, but are found free in an atmosphere of glowing metals, incandescent carbon or gas flames; they are driven off metals when exposed to ultra-violet light and are found around the discharge of any high voltage apparatus, or in air exposed to a discharge of X-Rays.

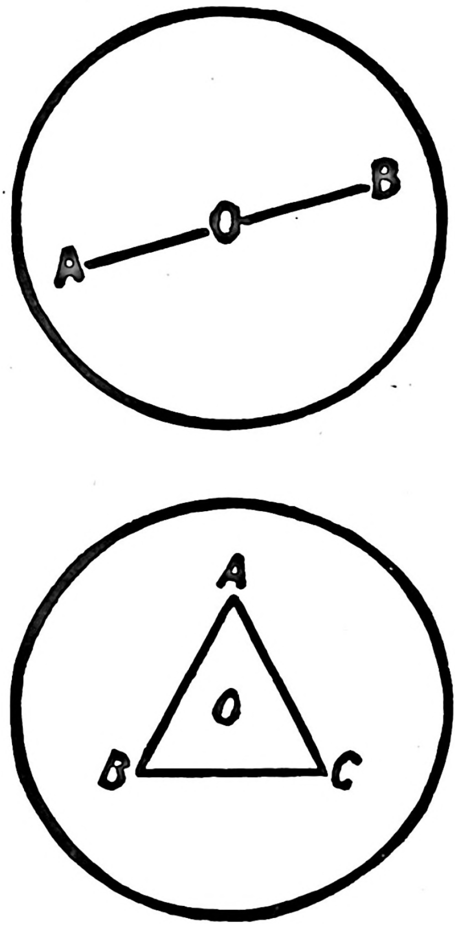


Fig. 3

No one knows what positive electricity is; it seems to exist in the form of particles the size of an atom, or in other words, it is an atom that has lost one electron. It has never been weighed, held in suspension, or its path photographed. It is known beyond doubt that negative electricity is contained in positive electricity, that the electrons are all inside of the atom, and that the outer shell of the atom is positive which balances the negative electricity or electrons within.

The foregoing paragraphs describe the nature of the electron in elements, and now we will describe the action of an electron in a vacuum.

In order to produce X-Rays, it is necessary to employ a current of high voltage. The negative and positive poles of the X-Ray tube are separated by a vacuum space within the glass bulb, and the object of the high voltage current is to offer potential enough to force the current across this gap.

The word "ion" will now be substituted for that of atom, as this is the proper term when referring to an atom in a vacuum discharge.

In a gas tube we have in addition to the electron and ion, the neutral ion which is neither negative nor positive. A neutral ion contains a fixed number of electrons, but it does not remain long in this state when in a vacuum discharge. The electrons are held tight in the neutral ion until it is absorbed a certain amount of energry, at which time one of the electrons is liberated, the ion then becoming positive.

To make this reaction clear, suppose an ion contains one hundred electrons and is then considered neutral. At a critical point it throws off one of these electrons and the ion then responds to a positive charge. The liberated electron roams around the tube, collides with neutral ions imparting energy to each one, and in time attaches itself to an ion and is absorbed. The ion now becomes neutral and in its turn moves around the tube colliding with other ions and electrons. After a certain number of collisions it has absorbed enough energy to throw off another electron. It is on this principle that the electrons are produced in a gas tube.

As the vacuum within a Coolidge tube does not change, there is necessity for a method of changing the resistance of this vacuum.

The electrical current must have something to carry it within the vacuum just as copper wires carry it from the mains to the coil or transformer. The high voltage current breaks down the insulating properties of the vacuum, ionizing the gas into ions and electrons which are the conductors of the current. In order to produce a continuous flow of electricity in a gas tube, it is necessary to have an equal number of ions and electrons; the ions making electrons and electrons making ions. As long as the proportion of these two is equal, the current will continue to flow. If the rate of recombination exceeds the rate of production, any electrons originally present in the tube will tend to disappear and the gas will cease to conduct electricity, if the rate of production exceeds the rate of combination, the number of electrons will increase and the gas will become a better conductor.

The fluorescence of a gas tube is due to the ions when the electrons are liberated. The speed of the ions traveling in an X-Ray tube ranges between 1,000 and 20,000 miles per second. The electrons when in the cathode stream travel at the rate of 37,000 to 90,000 miles per second, depending on the degree of vacuum and voltage.

The ions leaving the anode travel in two directions to the cathode, about ten per cent traveling in a straight line and 90 per cent traveling around the wall of the tube.

The current in a gas tube flows from the anode to the cathode carried first by the ions, which in turn produce electrons. The ions are first liberated from gas that collects around and in the anode. The liberated gases carry a positive charge and are ions. These ions are attracted to the cathode and there give up a large number of electrons.

These freed electrons in turn impart energy to the neutral ions which give up more electrons. The free electrons in time attach themselves to the ions and combine. The ions are attracted to the cathode and the electrons to the anode.

The electrons freed at the cathode are whipped into a stream by the current, and form what is known as the cathode stream.

When this cathode stream is suddenly stopped X-Rays are produced. In order to stop the cathode stream suddenly, it is necessary to have it strike an element of high atomic weight and high melting point. If an element of low atomic weight is used as an anode, such as iron, the cathode stream is not suddenly stopped but penetrates the

element and a very small number of X-Rays are generated. These rays would be lacking any great penetrative power.

On the other hand, if the anode is an element of high atomic weight and low melting point, it would be useless as the tube would be quickly destroyed by vaporization of the metal. In an element of high atomic weight the atoms are closely packed, and the cathode stream cannot penetrate, therefore is abruptly stopped at the surface and a large number of penetrative X-Rays are produced.

Tungsten makes a very good anode because the atomic weight and melting points are high. It is safe to estimate that the temperature at the tube's anode reaches between 7,000 and 8,000 degrees Fahrenheit.

The penetrative quality of X-Rays is controlled by the speed of the cathode stream, and this in turn is controlled by the voltage employed and the degree of vacuum or tube resistance.

It is a well known fact that deep penetrative rays cannot be obtained from a low vacuum tube, even if the voltage is high. It arises from the fact that in a tube of low vacuum there is a large amount of gas present, through which it is necessary for the stream to pass. This gas acts as a resistance to the passing of the stream and tends to decrease the speed, consequently weak penetrating rays are resultant.

If the vacuum in a tube is high, it means that there are very few molecules of gas present, that these do not retard the stream, and that when the stream strikes the anode it does so with a tremendous impact.

When the cathode stream strikes the anode it sets up ether waves or pulses of different lengths. These ether waves or X-Rays are generated at the anode surface and are focused by the angle of the target.

PHYSICS OF X-RAY PRODUCTION IN THE COOLIDGE TUBE

From the preceding pages it will be understood that there are three absolute essentials for the production of X-Rays in any X-Ray tube.

1. A means of producing electrons.
2. A high speed to their motion.
3. Some method of abruptly stopping the focused cathode stream composed of these electrons.

The Coolidge tubes, being exhausted to a much higher degree of vacuum than are gas tubes, are unable to operate successfully upon the electron production from gases contained within the bulb. Some other medium than the gas present is necessary in order that electrons in sufficient quantity may be obtained.

It being true that glowing metals throw off electrons, this idea was utilized by Coolidge in experimentation for the manufacture of the Coolidge tube.

In the cathode end of every Coolidge tube will be found a small tungsten filament resting snugly in a cylindrical molybdenum socket. This tungsten filament or coil is connected ordinarily to a low voltage transformer, and under action of this electricity, becomes heated to a point of brilliancy.

From this glowing metal there are thrown off quantities of electrons which, due to the high voltage current reaching the positive end of the tube, are forced into a high speed stream which is reflected from the cathode to the focal spot on the tungsten target.

As in the gas tube, this stream of electrons, focused by the cathode is known as the cathode stream.

When abruptly stopped by the tungsten anode, X-Rays are produced and their penetrative value is dependent upon the speed attained by the cathode stream. The speed of the cathode stream is in turn dependent upon the resistance within the tube and the voltage employed in its operation.

It would apply that the greater the speed of the cathode stream the more penetrative are the X-Rays produced at the target.

A resistance apparatus known as the filament control, interposed on the low voltage circuit to the tungsten filament offers this function. At desire of the operator, the amount of current reaching the tungsten filament is changed. This varied quantity of electricity brings about a change in the brilliancy of light and intensity of heat from the filament coil. Resultant there is control of the electrons thrown off from the tungsten coil which either raises or lowers the tube resistance.

As the current reaching the filament coil increases, the number of electrons thrown off from the coil becomes greater and the tube resistance is lowered allowing for a heavier input of current.

When equipped with the auto control, increasing the potential shows a slight advance in quantity of current up to that point where the filament is throwing off a maximum of electrons when the limit of tube capacity for current is reached. At this time the tube is carrying a maximum current due to the limitation in number of electrons possible to be given off from the filament coil and it is said to be carrying a saturated current.

The electrons given off from the filament coil directly govern the tube resistance which in turn determines back-up spark and current load.

Operating in this manner, the advantage of the Coolidge tube is manifest in that it allows for a changing of milliamperage and back up spark up to the limit of the tube capacity at all times.

Other than the manner of producing electrons within the bulb, vital principles of X-Ray production are the same in the Coolidge as in the gas tubes. Method of operation is of course different.

Due to the presence of the gas in a gas tube there is a fluorescence given off when the tube is in operation. The Coolidge tube lacking any great amount of gas within the bulb, there is no fluorescence manifest during operation of the tube other than the light given off by the tungsten filament. It must not be considered that these filament light rays affect the emulsion of film as do X-Rays, for this fluorescence is no different than that given off by any electric light.

The X-Rays are not seen.

Regardless of how low the resistance of the tube, it is never possible to see the cathode stream in a Coolidge tube. Again the gas presence in a gas tube accounts for this difference in characteristic.

The Coolidge tube will allow for continuous exposing up to the melting point of the tungsten target without changing the penetrative quality of X-Rays produced in the tube. This is a vast contrast to gas tube operation, realizing that the heat produced in a gas tube will change the tube resistance and consequently ample time must be given for cooling of gas tubes between exposure periods in order to prevent a loss of exposure accuracy.

Spinal exposures being unusually heavy as compared with other radiographic requirements, it is a decided advantage to Spinographers to utilize the advantage of continuous X-Ray production.

PART II

X-RAY TUBES AND THEIR ACCESSORIES

There are many kinds of X-Ray tubes in use today, but in our lecture we will consider the ones that have proven to be the most practical.

GAS TUBE

The gas tube has for description the following parts:

1. Bulb.
2. Anode, or positive end.
3. Cathode, or negative end.
4. Auxiliary stem.
5. Assistant anode.
6. Target.

1. The bulb is the large round part of the tube with a positive terminal on one end and the negative terminal on the other. This bulb contains the target which is in the center.

2. The anode or positive end, is the long narrow stem of the tube, containing a long steel jacket, which extends into the bulb and supports the target, which is placed at the end of it. Extending in from the extreme end of the anode we have a small wire which is attached to the steel jacket and carries the current in to the tube. The positive wire is attached to this end.

3. The cathode or negative end, is the large end of the tube. Contained in this end is a steel rod to which is attached a steel jacket. In this jacket is contained a con-

cave aluminum disc, the function of which is to reflect the cathode ray to the target producing the X-Ray. A small wire extends from the termination of the steel rod to the extreme end of the cathode; thus, the current is carried back to the machine. The negative wire is attached to this end.

4. The auxiliary stem extends outward from the upper or superior part of the bulb about the center. This auxiliary stem contains asbestos wooi, which is saturated with a gas forming chemical. The end of this stem serves to give attachment to the vacuum regulator wire.

5. The assistant anode is that part of the tube extending outward from the bulb and lying midway between the anode and the auxiliary stem. It contains an aluminum rod, at the end of which is attached a flat aluminum disc.

Extending from the anode to the assistant anode is a small coil wire which serves to carry current from the anode to the assistant anode and thence through the tube.

The target or anti-cathode, or anode proper, is made up of copper in the center of which is placed a button made of tungsten. This tungsten is about 5/8 of an inch in diameter and about 3/32 of an inch in thickness. It is on this button when the cathode ray strikes it, that the X-Ray is produced. The target is always placed at an angle of 45 degrees, so that the X-Ray is reflected down upon the patient on the table.

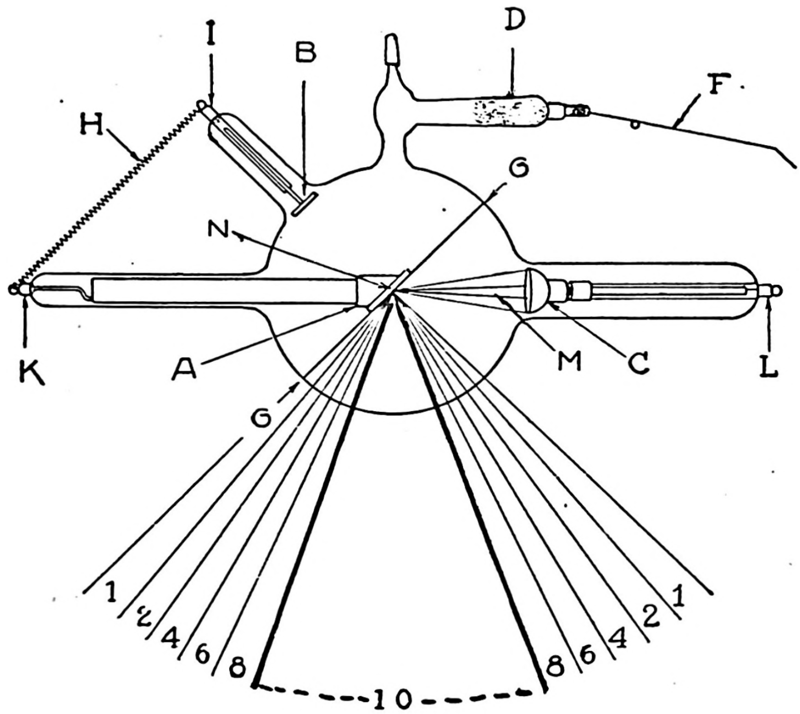


Fig. 4

DESCRIPTIVE PARTS OF GAS TUBE

A—Anode.
B—Assistant Anode.
C—Cathode.
D—Regulating Chamber.
F—Regulating Adjuster.
G—Hemisphere.
H—Connection Wire.
I—Assistant Anode Cap.
K—Anode Cap.
L—Cathode Cap.
M—Cathode Stream.
N—Focal Point.

The most rapid and effective rays are those reflected at right angles from the cathode stream forming a Focal

Point on the anode surface and shown graphically by the heavy cone "No. 10." The strength of the rays gradually decreases as indicated by the numbers "8-6-4," etc.

TESTING AND OPERATING OF A GAS TUBE

Gas tubes can be purchased that have a high, medium high, medium, medium low and low vacuum.

A high tube and a hard tube are synonymous. A low tube and a soft tube are synonymous.

It is well to have a high, medium and low tube, if one intends to do much X-Ray work; but a medium or medium high tube is used mostly in Spinography.

The life of a high tube for spine work is short compared with that of a medium or medium high tube, for this reason:

The penetration of a high tube is too great for spine work in the majority of cases. In order to reduce a high tube to its proper vacuum or internal resistance for this work, a large quantity of the gas-forming chemical is consumed in the auxiliary stem. This must be done continually before making an exposure to keep the proper vacuum.

Now by constantly doing this, the chemical will soon be exhausted after which it will be almost impossible to reduce this vacuum and in attempting it the tube is likely to puncture and, as a result, it will be necessary to return the tube to the manufacturer for refilling, or a new regulator, as a tube becomes useless unless the regulator is

refilled. Re-pumping a tube lowers the efficiency, unless a new cathode is inserted.

A high tube is very seldom used except in such cases as dropsy, real fleshy individuals, or fluoroscopy, or where deep penetration is required.

A medium, or medium-high tube, as stated before, is just the proper vacuum for spine work and does not necessitate a constant excessive reduction. It will not be necessary to use very much of the chemical in the asbestos wool and, as a result, the life of the tube will be much longer than that of a high tube.

A low tube, if used with caution, may be used for exposures that do not require any great penetration, such as radiographs of the hand, forearm, foot, ankle and leg, or radiographs of very small children. If a tube of this kind is operated until the bulb is quite warm, many times the vacuum will increase until it is suitable for Spinography, and it will be found a very stable tube, seldom requiring regulating. A tube of this type can be used successfully for Spinographic work if the intensifying screen is being used.

The number of **milli-ampere seconds** and the **back-up spark**, or **degree of penetration**, are the first two things to be taken into consideration before making an exposure. Determine the amount of milli-ampere seconds and the back-up spark required by observing the patient and noting the depth and kind of tissue to be penetrated.

CIRCULATION OF CURRENT THROUGH THE GAS TUBE

When the X-Ray switch is closed, current from the high tension winding of the coil or transformer passes to the anode end of the tube. The current passes into the anode end and some passes over the small coiled wire to the assistant anode where it enters.

The current flows across and around the bulb of the tube and strikes the cathode disc. The disc is concave and part of the current is reflected to the target. This reflection from the disc to the target is called the cathode ray. When the cathode ray strikes the target it generates the X-Rays.

This target being placed at an angle of 45 degrees, the X-Rays are reflected downward to the object on the table.

The current passes out through the cathode and over the negative wire to the machine, thus completing the cycle.

HOW TO RAISE THE VACUUM OF A GAS TUBE

Detach the wire from the anode to the assistant anode. Then attach the positive wire to the assistant anode, leaving the negative wire connected to the cathode end. Have the rheostat on button one. Insert the X-Ray switch and allow the current to pass into the tube for 15 to 20 minutes, or until the tube begins to get warm around the cathode disc. Allow the tube to rest for five or six hours. Repeat this operation several times and let the tube rest a few days

before using. This method may or may not be successful. If not, the tube must be sent to the manufacturer for re-pumping.

HYDROGEN X-RAY TUBE

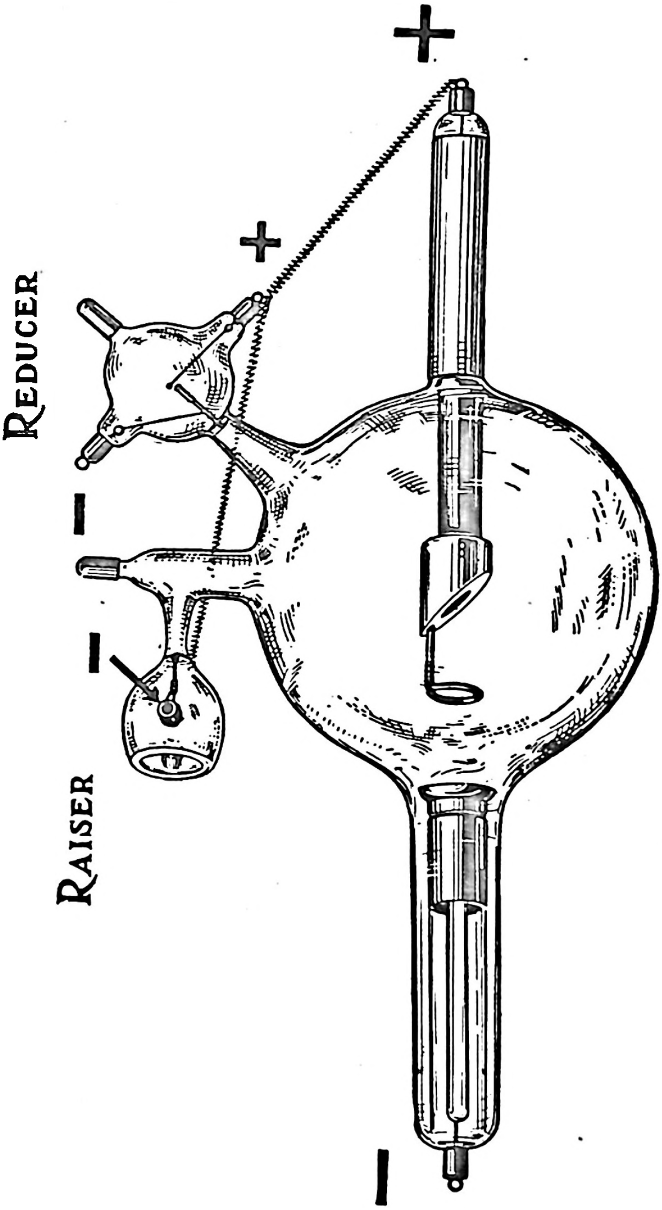
This is another type of an X-Ray tube which is similar in construction and action to the common type of gas tube, with the exception that it has a reducer in place of the assistant anode and a raiser in place of the auxiliary stem, and that it may be raised or lowered in vacuum.

DESCRIPTION

Following is a description and instructions for using this type tube.

1. To lower the vacuum, pass through the reducer about 15 milli-amperes, five or ten seconds, at a time. Repeat if necessary. Do not use more current; **use more time.** Always maintain polarity as indicated by the polarity indicator.

2. To raise the vacuum, pass through the raiser about 25 milli-amperes (never more than 30 milli-amperes), twenty seconds at a time. If the vacuum is below ⅛ inch, disconnect spiral temporarily from positive (x) terminal of raiser. Connect anode wire to positive (X) terminal of raiser and cathode wire to negative (—) terminal of raiser. Run three minutes with 22 to 25 milli-amperes. Repeat if necessary. Replace spiral.



HYDROGEN TUBE

Figure 5

3. **To regulate the tube** before making exposure; it should test out at a two-inch vacuum with low current (about 5 milli-amperes). This may vary with some machines.

4. The normal tendency of the vacuum is to raise a trifle during the first exposure when the tube is cold. To compensate for this, introduce a little more gas.

5. **The focal plate distance** of 24 inches is the best and is being used in common practice with the conventional cone.

6. Thirty M. A. is specified because a medium focus anode will give much more **service** than with 45 to 50 milli-amperes. Less current can be used with more time provided spark gap is correct.

7. **A sharp focus tube** should be limited to 20 milli-amperes, 5 inch spark gap.

8. Use a **broad focus tube** for extremely **fast exposure** in making stomach and intestinal plates.

9. Forty M. A. x 3 Sec. means 40 milli-amperes, three (3) seconds or 120 milli-amperes seconds.

Forty M. A. x 1½ Sec. means 40 milli-amperes, one and one-half (1½) seconds or 40 milli-ampere seconds.

10. **Modify exposures:**
   - A. Weight of a patient increases the time if the patient weighs more than 150 pounds.
   - B. Increase the time if a slow plate is used.

C. Increase the time if the focal plane distance is more than given on the chart which is supplied with the tube.

D. Increase the time if more density is desired.

E. If an intensifying screen is used, cut the time down to about one-third or one-sixth, depending on spark gap and speed of screen.

COOLIDGE X-RAY TUBE

GENERAL DESCRIPTION

The Coolidge X-Ray Tube consists of a tube exhausted to a pressure of not more than a few hundreds of a micron (a micron is 0.001 mm.) in which is supported a cathode so arranged that it may be heated electrically; an electrically conducting cylinder or ring connected to the heated cathode and so located with reference to it as to focus the cathode rays on a target, and an anti-cathode or target which functions as an anode.

CHARACTERISTICS

The important characteristics of the Coolidge Tube are the following:

1. No discharge current through the tube unless the filament is heated.

2. The amount of discharge current is determined primarily by the amount of current passed through the filament and hence by the temperature produced.

3. The penetrating power of the X-Rays is determined by the voltage across the tube terminals.

4. The starting and running voltages are the same.

5. The allowable energy input is determined by the size of the focal spot.

6. Continuous operation is possible without change of characteristics.

7. The focal spot is fixed in position.

TYPES

Coolidge X-Ray Tubes are manufactured in three different types:

Universal Type, Coolidge X-Ray Tube.

Radiator Type, Coolidge X-Ray Tube.

Radiator Dental Type, Coolidge X-Ray Tube.

UNIVERSAL TYPE COOLIDGE X-RAY TUBE
DESCRIPTION OF UNIVERSAL TYPE
DIMENSIONS

The bulb of the universal type tube is 7 inches in diameter. The over-all length is approximately 20 inches.

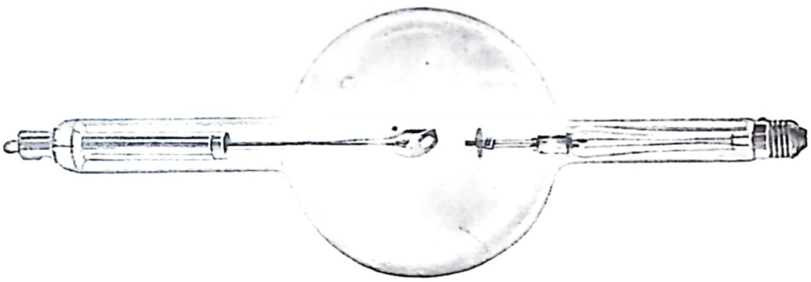


Figure 6—Universal Type Coolidge X-Ray Tube

THE CATHODE

The filament (A), Figure 7, which forms the cathode, consists of a closely wound spiral of tungsten wire.

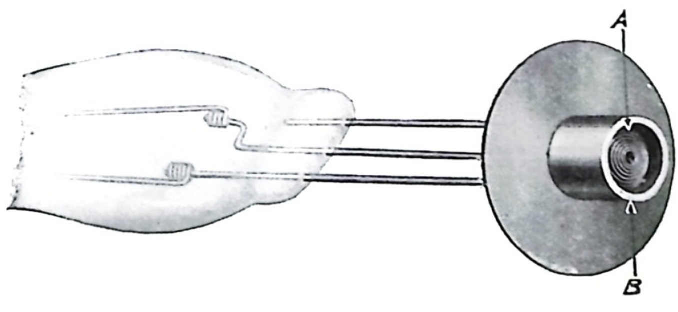


Figure 7—Cathode of Universal Type Coolidge X-Ray Tube

FOCUSING DEVICE

This consists of a cylindrical tube of molybdenum (B), Figure 7, with a flange, mounted concentric with the tungsten filament and with its inner end projecting about 0.5 mm. beyond the plane of the latter. Besides acting as a focusing device it also prevents any electron discharge from the back of the cathode.

ANTI-CATHODE OR TARGET

The anti-cathode or target, Figure 8, which also serves as an anode, consists of a single piece of wrought tungsten (C) attached to a molybdenum rod (D) and supported by a split iron tube (E).

Figure 8—Anode of Universal Type Coolidge X-Ray Tube

METHOD OF HEATING CATHODE FILAMENT

The cathode filament may be heated by means of a storage battery or a small transformer. The battery is universally applicable. The transformer may be used wherever there is alternating current available, either from the supply mains or from a sunchronous converter.* The filament current transformer is not to be recommended for radiographic work where there is much line drop or fluctuation in the current supply.

*The terms synchronous converter is used to designate what is sometimes known as "a rotary" or "a rotary converter."

The transformer is generally used wherever alternating current is available. This transformer should have a low tension output of 10 to 12 volts and not over 5 amperes. It should be capable of finely graduated control by means of either a resistance or variable inductance device. As the low tension side of this transformer will be brought to the full potential of the tube, it is important that it be thoroughly insulated from the high tension side, the ground and the patient.

The storage battery may be used where there is no source of alternating current or where on account of fluctuation of voltage and line drop, the use of a transformer is unsatisfactory.

The storage battery should be a 5- or 6-cell (10- or 12-volt) 40-ampere-hour battery, and arrangements should be made so that the battery may be connected during the night to the charging circuit. Before using the tube for the first time each day, the filament circuit should be closed for a few minutes. This allows the battery to reach a stable condition and so eliminates fluctuations in the filament current. (A fully charged storage battery shows 2.5 volts per cell, dropping raidly to a stable point of 2 volts.) It is inadvisable to charge the battery at frequent intervals during the day owing to the trouble from instability in voltage referred to above.

If battery leads other than those furnished with the tube are used they should not be of greater resistance than these. Leads of too great length will add enough resistance to the filament circuit so that additional cells of battery may be needed. This may be corrected by the use of heavier wire.

Whether the battery or transformer is used for heating the filament, the best technic demands the use of an ammeter in the filament circuit. The meter should have a 5-ampere scale large enough to be easily read to the nearest hundredth of an ampere.

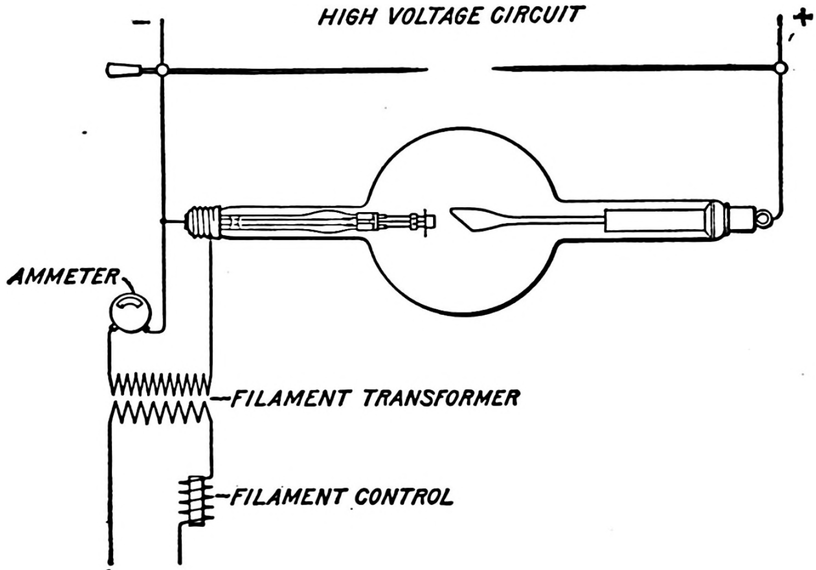


Figure 9—Wiring Diagram of Cathode Circuit

The above diagram, Figure 9, shows the wiring and control of the filament heating circuit where the transformer is used and where control is obtained by the use of a variable inductance device placed in series with the primary coils of the filament transformer.

HIGH TENSION CIRCUIT

Sources of Current Supply

The Universal Coolidge Tube may be operated in connection with the following devices for the production of high tension electricity, the static machine, induction coil or high tension transformer.

Rectification of Current

This tube will successfully rectify its own current provided the energy input is not such as to heat the focal spot or any part of the focal spot to a temperature approximating that of the cathode filament. In practice, however, it has been found impossible to restrict the use of the tube to comply with the above conditon. *For this reason, we recommend the use of this tube only with rectified current.*

The tube should never be operated in connection with a transformer or an induction coil, without the interposition of a suitable valve tube or mechanical rectifier.

Control of Current

When a high tension transformer is used, control of the output may be secured either by means of a variable resistance in series with the primary, or an auto-transformer.

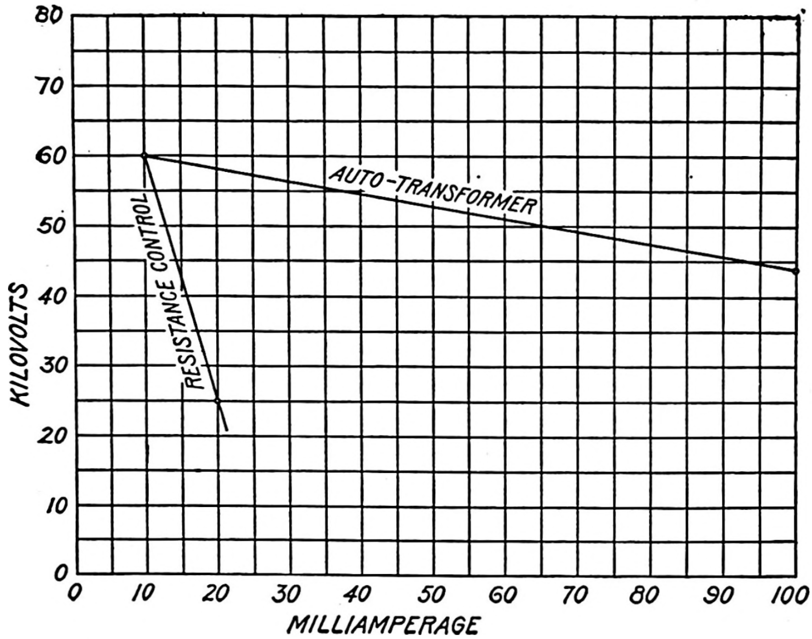


Figure 11—Curve Showing Comparison of Results Obtained by Use of Resistance and Auto-Transformer Controls

In diagnostic work, it has been found that it is almost impossible to obtain duplication of results when a series resistance control is employed for this purpose. We recommend that an auto-transformer be used for control for all diagnostic work and resistance control for therapeutic work.

With either method of control, it is advisable to have a quick acting circuit breaker in the primary side of the high tension transformer to immediately open the circuit in case of any accidental ground in the high tension circuit.

Reference to the curves shown in Figure 11, will show the results secured by the use of a resistance control, as compared with the use of an auto-transformer.

Capacity of the Tube

Capacity refers to the amount of energy that a tube will carry. Energy may be considered as the produce of the voltage (spark gap) multiplied by the milliamperage. The allowable energy input is determined principally by four things: (1) target material, (2) area of the focal spot, (3) time during which the energy is applied, (4) temperature of the target at the beginning of operation.

The metallic tungsten used for the target face of the universal type tube has a melting point of about 33 degrees C. Energy must not be applied in quantities sufficient to raise the focal spot to that temperature. As approximately 99.8 per cent of the energy applied to the focal spot is converted into heat, the limit of the allowable energy input is the amount of heat which can be removed from the focal spot and dissipated by the tube.

The greater the area of the focal spot, the larger the amount of energy which may be applied to it.

The Universal Type Coolidge Tubes are classified in accordance with the size of the focal spot and are made in three sizes, fine, medium and broad focus. The fine focus tube is recommended for fluoroscopy and for radiographic work where sharp definition is desired and heavy currents are not required. The medium focus tube will be found suitable for most radiographic, fluoroscopic and light therapeutic work. For deep therapy and radiographic

work where heavy currents are required, the broad focus tube should be used. As the allowable energy input is determined by the size of the focal spot, it is advisable always to keep the amount of current used within the following limits, as by so doing the operator is in general assured of satisfactory operation and long tube life. Based on the voltage corresponding to a 6-inch spark gap between points, the fine focus tube should not be made to carry more than 25 milliamperes of current, the medium focus 50 milliamperes and the broad focus 80 milliamperes. If possible, it is always advisable to start exposures with the target cold, or at a temperature below that corresponding to visible redness when the energy input approaches these limits. The tube may be operated at either greater or less voltage, as indicated by the parallel spark gap, but the current should be correspondingly increased or decreased so that the total energy input never exceeds the limitation given above.

The above considerations apply to the tube when used for radiographic work. For continuous operation in radiotherapy, the limiting factor is not so much the target as the glass of the bulb. It is possible to get the body of the target so hot that heat radiated from it may cause gas to be driven out of the glass or may even melt the glass. Adequate cooling of the bulb by forced air circulation is necessary to prevent this.

METHOD OF OPERATION

The filament must always be lighted before high tension current is applied to the tube. This precaution is more for the safeguarding of the patient and the apparatus

than for protection of the tube. This applies to tubes whether operated in connection with induction coils or high-tension transformers.

The technique of various operators and the sources of excitation vary so much that it is difficult to make detailed suggestions which are universally applicable.

The following general considerations, however, may be of value:

The higher the filament current, the greater the milliamperage.

The higher the voltage backed up by the tube, the greater the penetration.

A simple method for starting radiographic work with the tube is as follows:

Take a case, for example, where the operator has been doing his work with the high tension transformer control on the tenth button with his tube drawing 30 milliamperes. In this case, all that is necessary with the Coolidge Tube is to light up the filament having the filament control set for the least possible amount of current, set the high tension transformer control on the tenth button, close the main switch and adjust the filament control until the tube is drawing 30 milliamperes.

Having once adjusted the tube to this condition, the operator should read and record the amperage in the filament circuit. To reproduce the condition he then needs merely to adjust the filament current to this same value and set his high tension transformer control on the same

button. In this way, after his technique is once established, he never tests the tube by operating it, but is guided solely by the ammeter and the high tension transformer control button. While this method is generally applicable, it is not universally so, as it will be found that with certain types of generators the same control button and the same milliamperage as has been used with other tubes will not give the same penetration.

In other cases, the radiographer will be accustomed to adjust his tube by means of the milliammeter and the parallel gap. This procedure can be applied equally as well to the Coolidge Tube, and will naturally be the one first used in all cases where the operator is not familiar with his machine. Knowing that he wants, for example, 20 milliamperes and a 5-inch parallel gap, he will start with the filament control adjusted for the lowest possible current. He will then adjust the filament control and run up to higher buttons on the main control until the tube is drawing 20 milliamperes and backing up the 5-inch gap. As before he will then read and record the amperage in the filament circuit and the number of the control button and will be subsequently guided solely by this.

When excessively high energy inputs are employed, the tungsten at the focal spot melts and volatilizes. This results in a sudden lowering of the tube resistance which disappears instantly upon lowering the energy input, but the vaporized tungsten deposits in a thin film over the active hemisphere of the tube. (This mirror-like metal deposit on the inside of the glass should not be confused with the violet coloration which always results when the particular kind of glass used in these bulbs is subjected

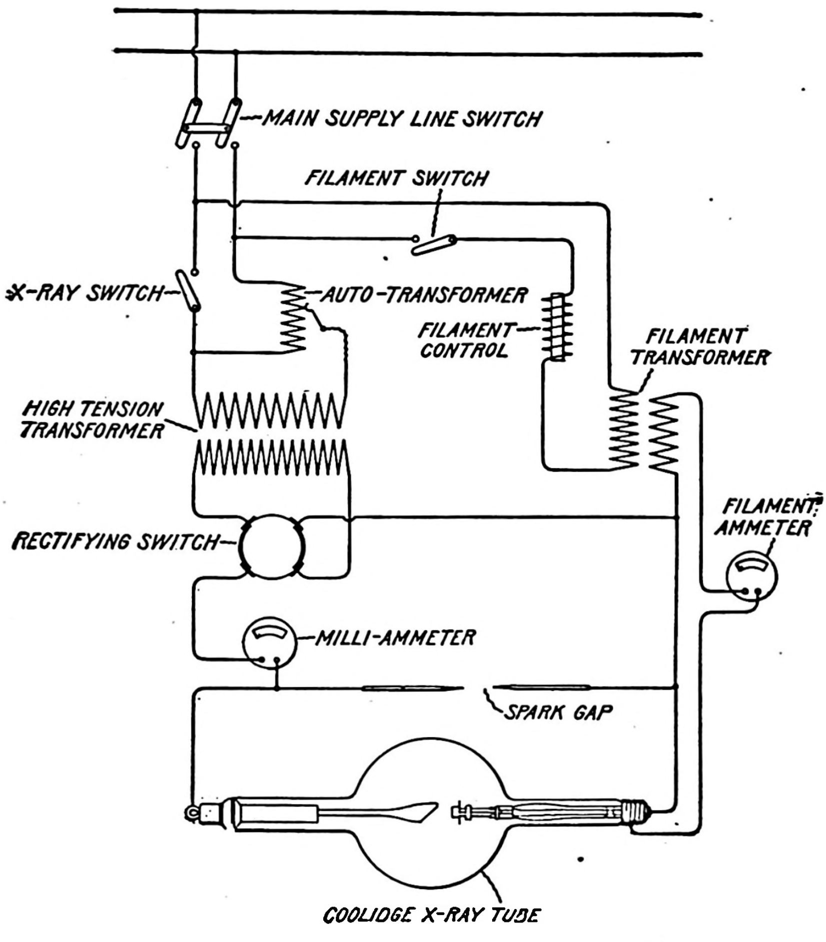


Figure 12—Wiring Diagram of Universal Type Coolidge X-Ray Tube on Rectified Current

to prolonged exposure to X-Rays. This violet color is due to some change taking place within the glass itself and is perfectly harmless.) The thin film of tungsten exerts no appreciable filtering effect upon the X-Rays, but it does disturb the electrical conditions within the tube. Experiments have shown that a grounded metal wire may be brought up into actual contact with a clean bulb when the tube is operating, whereas with a tube having a metal deposit inside, such a wire must be moved away a number of inches to avoid puncturing the tube. The metal of the tube stand is usually grounded and the number of punctured bulbs would be greatly reduced if the practice of blackening bulbs were discontinued and if care were taken to avoid approaching the metal of the tube stand any nearer the bulb than is absolutely necessary. Furthermore, this practice results in no appreciable gain. It may succeed in increasing X-Ray production a few per cent, but at the same time, it greatly reduces the life of the tube.

The tube must not be run with voltages higher than that corresponding to a 10-inch spark gap between points (that is, it should not be made to back up more than a 10-inch parallel gap.)

GENERAL REMARKS ON UNIVERSAL TYPE TUBES

Appearance of the Bulb

While Coolidge Tubes are being exhausted they are operated up to a point that is just within the maximum limits of the tube, that is, the energy input is such that the anode is kept at white heat during exhaust without melting the focal spot of the target. Inasmuch as a con-

siderable period of time is required for exhausting a tube, it can readily be seen that a large quantity of X-Rays will be given off from the tube during this exhaust.

Glass is readily discolored by the action of the X-Rays and different glasses will discolor differently under this action depending upon the constituents in the glass itself. For example, glass containing manganese will be colored amethyst due to the action of the X-Rays on that particular constituent of the glass, and in a similar manner, lead glass will be colored brown. This latter case is very well demonstrated in the brown color noticed in all the lead glass protective bowls of the tube stands, which have been in use for any length of time.

The glass used for the bulbs of the Coolidge X-Ray tubes contains some manganese and the purplish or amethyst color of the bulb which is noticed in new tubes is due to the effect of the X-Rays given off from the target during the operation of the tubes while being exhausted. This discoloration in no way affects the satisfactory operation of the tube.

Appearance of the Target

There is generally a frosted area in the center of the target face of a new tube. This is due to a crystallization of the tungsten during the exhaust of the tube and the size of this area is not an indication of the size of the focal spot.

Fluorescent Phenomenon

During the operation of some universal type tubes there will be noticed a clearly defined red band at the

junction of the anode head and the molybdenum supporting rod. This red band is merely the fluorescent effect produced by the action of the reflected cathode rays upon the microscopic particles of abrasive material which are deposited in this junction during the process of grinding the anode.

RADIATOR TYPE COOLIDGE X-RAY TUBE

The radiator tube is designed solely for diagnostic purposes and is recommended for fluoroscopy and radiography only. It should never be used for therapy.

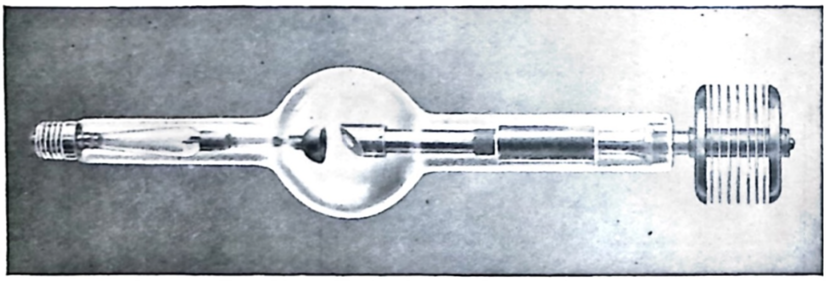


Figure 13—Radiator Type Coolidge X-Ray Tube

CHARACTERISTICS

The physical characteristics of this tube are in general the same as those of the Universal Type Tube. There is this important difference, however, that the Radiator Type Tube is capable of rectifying its own current. It may, therefore, be operated directly across the terminals of either an induction coil or a high tension transformer without

the interposition of any auxiliary rectifying device. In construction, it is quite different from the Universal Type Tube.

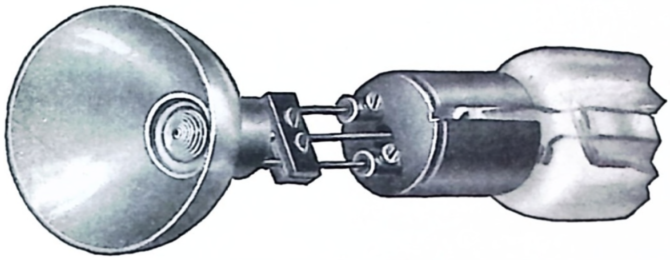


Figure 14—Cathode of Radiator Type Coolidge X-Ray Tube

DESCRIPTION OF RADIATOR TUBE

Bulb

In the Radiator Type of Tube, by far the greatest part of the heat imparted to the target is conducted to the copper radiator, instead of being radiated through the glass wall of the bulb as is the case with the Universal Type Tube. It is, therefore, possible to make the glass bulb of the Radiator Type Tube quite small. The bulb measures 3¾ inches in diameter and the over-all length of the tube is approximately 19 inches.

Cathode

The filament, Figure 15, which forms the cathode of this tube, is similar to that of the Universal Type Tube.

Focusing Device

This consists of a cylindrical tube of molybdenum to which is attached a hemispherical cup of the same metal. By means of this construction a small focal spot with a very uniform distribution of energy is secured.

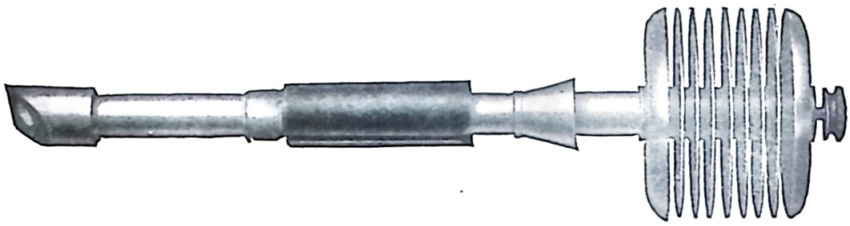


Figure 15—Anode of Radiator Type Coolidge X-Ray Tube

The Anode

The anode stem consists of a solid bar of copper 1.6 cm. (⅝ inch) in diameter which is brought out through the glass of the anode arm to a copper radiator. The head of the anode consists of a mass of specially purified copper which is first cast in vacuum on to a tungsten button and is then electrically welded to the stem. The tungsten button, which receives the cathode ray bombardment is 2.5 mm. (0.1 inch) thick and 9.5 mm. (⅜ inch) in diameter.

The complete target with radiator weighs 860 gm. and has a heat capacity of 81 calories per degree Centigrade; while the present standard solid tungsten target, complete with molybdenum stem and iron supporting tube, has a heat capacity of less than 10 calories. Because of its greater heat capacity, it takes, with a given energy input, much longer to heat the Radiator Type of target to a given temperature than it does the solid tungsten target.

What is much more important, however, is the fact that between radiographic exposures, the target in the Radiator Type cools comparatively rapid owing to the large copper stem and the radiator.

The importance of having the target cold at the start is shown by the following experiment: It was found that with a tube having a given size focal spot and a solid tungsten target, it was possible, when beginning with the target at room temperature, to run about four times as long with the maximum, allowable energy input, before damaging the tube as a result of "inverse" current, as it was when the experiment was started with the target at dull red heat.

METHOD OF HEATING THE CATHODE

The filament of this tube is heated in the same manner as that of the Universal Type Tube.

THEORY OF OPERATION

In the Radiator Type of tube, the passage of "inverse" current is avoided by a construction which removes heat from the focal spot so rapidly that, in normal use, it never reaches the temperature at which an appreciable thermionic emission of electrons can take place.

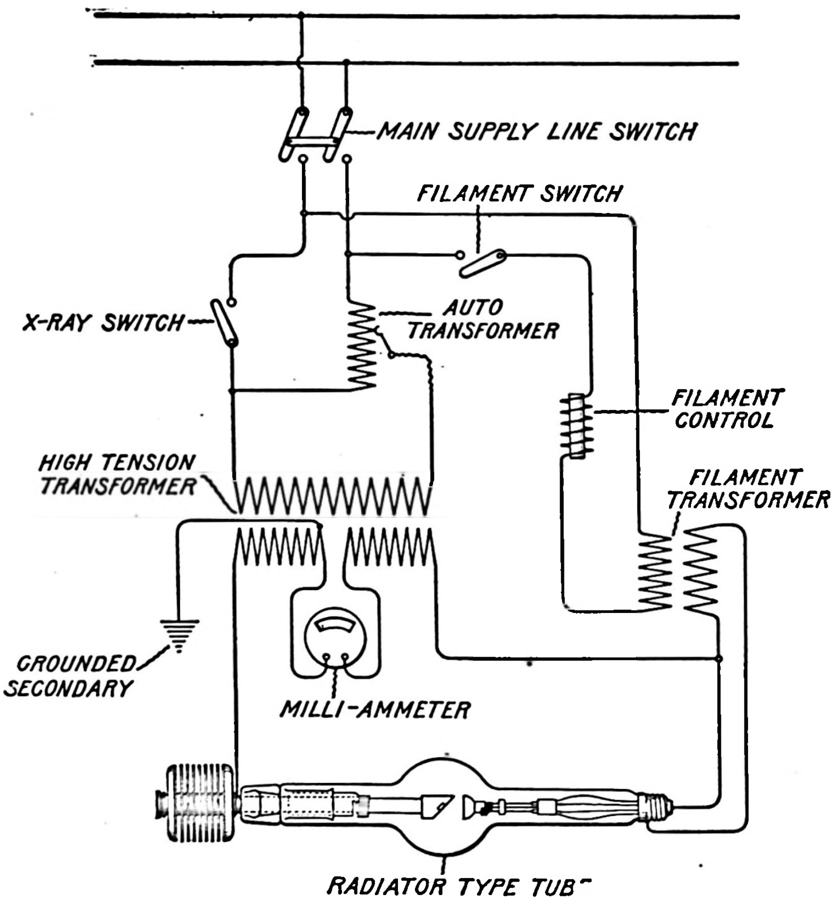


Figure 16—Wiring Diagram of Radiator Type Coolidge X-Ray Tube on Unrectified Current

In addition, in this type of tube, the temperature of the focal spot may be raised to that of the cathode spiral and even brought to the fusing point, while the tube is operating on alternating current, without the tube allowing any appreciable "inverse" current to pass. This last fact is probably explained by the presence of gas in the copper tungsten anode and to the effect of this gas in reducing the thermionic emission of electrons from the focal spot.

HIGH TENSION CIRCUIT

Although this tube is self-rectifying and may be operated directly across the terminals of a high tension transformer or induction coil without the interposition of auxiliary rectifying devices, it will operate equally well on types of apparatus which deliver rectified high tension current.

Whether operated on rectified or unrectified current, the use of the auto-transformer as a means of control is recommended.

Fig. 16 shows a wiring diagram of a Radiator Tube operated directly across the terminals of a high tension transformer and showing the auto-transformer method of control.

CAPACITY OF THE TUBE

The important limiting factor of allowable energy input for the Radiator Tube is the area of the focal spot. On account of the special construction of the anode of the Radiator Type Tube, the heat from the target is rapidly

conducted to the outside of the tube and dissipated by the copper radiator. This design insures that operation is always started with a comparatively cool target. The combination of great heat capacity and the ability to quickly conduct and radiate heat from the target makes it possible to apply a greater amount of energy to a given focal area than the Universal Type Tube. For a given capacity the focal spot of this type of tube is much smaller than is possible with the Universal Type Tube.

The energy limitation of each Radiator Tube will be found marked on the tube and care should be taken that this limit is not exceeded, otherwise the tube will be damaged.

Where only milliamperage is marked, it indicates that the tube may be operated at an energy corresponding to the marked current and the voltage corresponding to a 5-in. parallel spark between points.

Each Radiator Tube is designed to carry the amount of energy indicated by the markings, for a period of time sufficient for making diagnostic radiographs which require the longest exposure or to carry a fluoroscopic load of 5 milliamperes, at a voltage corresponding to a 5-in. spark gap.

The tube should never be operated in such a manner as to heat the body of the anode beyond a temperature corresponding to a dull red heat.

METHOD OF OPERATION

When operating the Radiator Tube on machines delivering rectified current, the same general instructions

apply as for the Universal Type Tube, taking care, however, that the energy limitation of the tube is never exceeded.

When operating this tube rectifying its own current, the change of conditions makes necessary certain changes in methods of operation.

The Spark Gap

Upon operating the tube directly from the secondary of a transformer, the "inverse" voltage is always higher than the "useful" voltage. Consequently, the measurement of the tube voltage by a parallel spark gap used in the ordinary way would, in general, be very misleading, as the observed spark length corresponds to the "inverse" voltage and not to that which produces the X-Rays and hence determines their nature.

Apparatus

Apparatus for operating this tube rectifying its own current is usually designed to furnish a voltage corresponding to a 5-in. gap between points. Experience has shown that if all radiographs are taken with the same voltage, the **average** quality and diagnostic value is better than if an attempt is made to vary the voltage.

The same has been shown to be true for variations of current through the tube. We, therefore, recommend that the Radiator Tube be operated always with the same voltage (back-up spark) and milliamperage. This should be the maximum capacity for which the tube is designed as indicated by the markings.

When operating a tube in this manner, it is also convenient to use always the same distance between focal spot and plate for most radiographs. This reduces the number of variable factors which influence the making of a radiograph to one, namely, the time of exposure. The operator having a machine and the tube once set to work at a fixed rate of, say, 5-in. back up and 10 milliamperes and a fixed focal-spot distance of 18 in., has his mind entirely free to devote to proper posing of the part to be radiographed. Once posed, he has only to decide the time of exposure necessary and close the switch for that length of time. For example, with the settings made as above, if the part to be radiographed is a hand or wrist, the operator has only to close the switch for 1 sec. For a medium sized knee, 5 sec.; for a shoulder, 10 sec. If the shoulder is thicker than medium size, 12 sec., or even 14 sec. might be necessary, and if thinner than medium size, 8 sec. will perhaps be sufficient.

The matter of the thickness of the part and the time of exposure may best be determined by the judgment and experience of the operator. The figures given above are intended only as an illustration of the method and not as a guide for the making of radiographs.

Fig. 17 shows the radiator tube enclosed in the lead glass protective shield.

This shield is made of glass containing enough lead so that, for the same protective effect, it is but four times as thick as sheet lead. The walls of this shield are ¼ in. thick, giving X-Ray protection equivalent to metallic lead 1/16 in. thick.

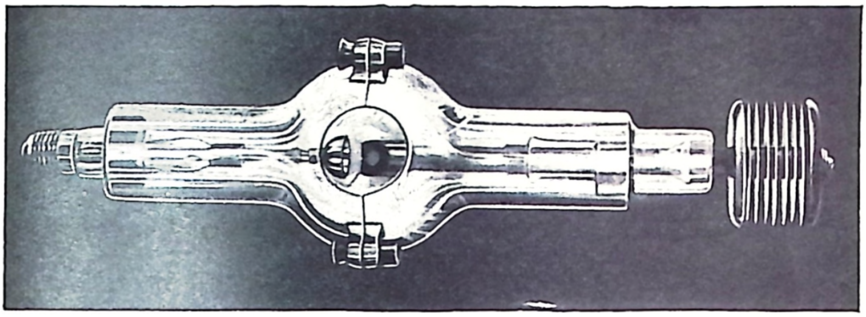


Figure 17—Radiator Type Coolidge X-Ray Tube Enclosed in Lead Glass Protective Shield

This shield is made in two halves which are identical and interchangeable. The joint is ground and is made at right angles to the long axis of the shield. It is evident that even if the joint does not fit tightly, no X-Rays can escape unless the focal spot happens to be centered directly in line with the ground surfaces.

The outer ends of each half of the shield are threaded to take the screw caps. These caps force tapered split bushings of cork in between the arms of the X-Ray tube and the shield. This holds the tube securely in position in the shield and prevents rotation.

The use of this shield is recommended in cases where adequate X-Ray protection is not otherwise afforded.

RADIATOR DENTAL TYPE COOLIDGE X-RAY TUBE

The Radiator Dental Type Coolidge X-Ray Tube is designed for dental work and is furnished for use only on types of apparatus which are specially designed for operating this tube. It is intended for making radiographs of

the teeth and jaw, only, and is not intended to be used for general radiographic work.

CHARACTERISTICS

The physical characteristics of this tube are the same as those of the Radiator Type. It is self-rectifying within the limits of its allowable energy input.

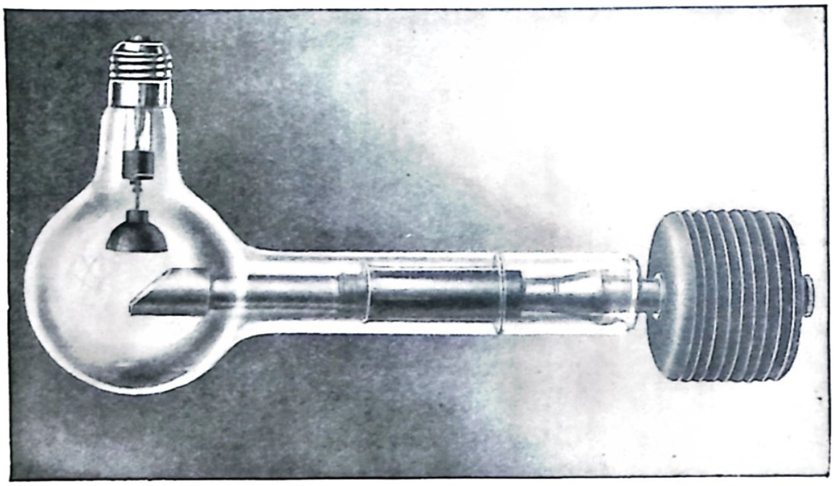


Figure 18—Radiator Dental Type Coolidge X-Ray Tube

DESCRIPTION OF RADIATOR DENTAL TUBE

This tube is similar to the Radiator Type tube except for a few important differences of form and construction which have been adopted for the purpose of especially adapting this tube to the work which it is expected to perform.

The cathode, focusing device and anode of this tube are the same as are used in the Radiator Tube.

The bulb of this tube measures 3¾ in. in diameter; the cathode arm extends 2 in. from the bulb at a right angle to the anode arm which measures 9 in. from the bulb to the end of the radiator. The advantages of this type of construction are: rays are emitted from the tube in a line with the axis of the anode, thereby making it easy to manipulate the tube to the best advantage; the cathode circuit is grounded so that there is only one high tension wire and that is always connected to that part of the tube which is farthest from the subject to be radiographed. This form of construction makes it possible to reduce the film to focal-spot distance to a minimum.

The short film to focal-spot distance makes it possible to obtain satisfactory radiographs of the teeth and jaws with comparatively short exposures.

THEORY OF OPERATION

The theory of operation of the Radiator Dental Type Tube is the same as that of the Radiator Type Tube.

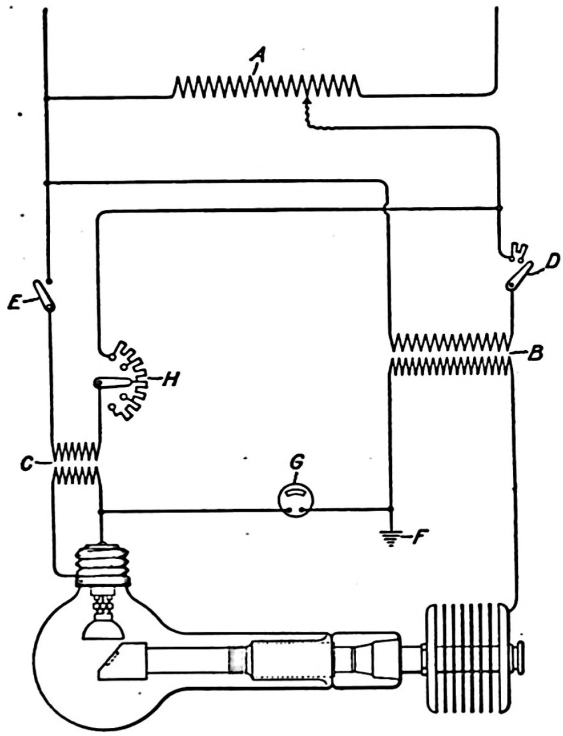


Figure 19—Wiring Diagram of Radiator Dental Type Coolidge X-Ray Tube Circuit

Coolidge Dental X-Ray Tube Wiring Diagram:

A Auto-transformer—1/120 volts
B X-Ray transformer
C Filament transformer
D X-Ray switch with resistance
E Filament switch
F Ground connection
G Milliammeter
H Filament control

HIGH TENSION CIRCUIT

The Radiator Dental Tube is intended to be operated only on machines specially designed for dental work in connection with this particular type of tube.

Fig. 19 shows the wiring diagram of such a machine and the wiring scheme indicated in this diagram is generally followed out by manufacturers of all such machines.

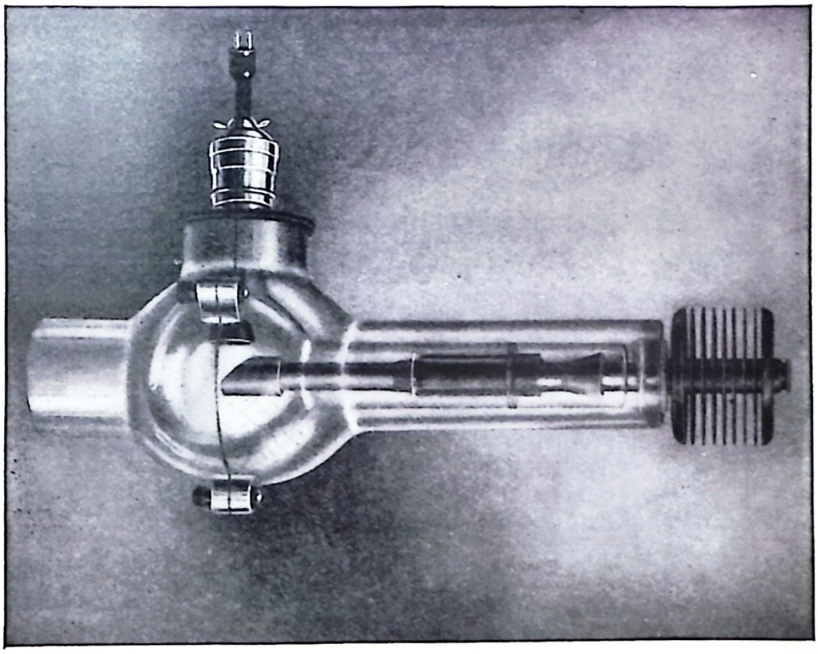


Figure 20—Radiator Dental Type Coolidge X-Ray Tube Enclosed in Lead Glass Protective Shield

CAPACITY OF THE RADIATOR DENTAL TYPE TUBE

The Radiator Dental Tube is designed to be operated at all times with an energy input not exceeding that corresponding to a current of 10 milliamperes at a "useful" voltage corresponding to a 3-in. parallel spark gap between points.

METHOD OF OPERATION

As this tube is designed to operate only in connection with special machines, and always at a fixed voltage and current, operation is limited to closing the switch for a length of time necessary to produce on the photographic film the effect desired by the operator.

The factor of time is the only variable in the making of radiographs with this tube and this factor will be adjusted in accordance with the judgment and experience of the operator.

It will be noted that the cathode terminal of the dental tube is connected direct to the "ground" which makes it possible to approach the tube very near to the patient without danger of shock.

The anode end, during operation, is at the maximum potential and is that part of the tube which is always farthest away from the patient. The short distance between the focal spot and film makes it possible to take satisfactory radiographs of the teeth and jaws with very little expenditure of energy.

Using an 8-in. focal-spot film distance the photographic effect may be secured with one-fourth the energy which would be necessary if the distance were 16 in.

Fig. 20 shows the radiator dental tube enclosed in the special lead glass protective shield.

This shield is designed to hold the tube firmly and to give ample X-Ray protection.

GENERAL NOTES

MEASUREMENT OF VOLTAGE WITH TUBE OPERATING ON RECTIFIED CURRENT

In order to properly determine the voltage applied to a Coolidge X-Ray tube, by means of a spark gap between points, erroneous conclusions should be avoided by observing the following instructions:

1. Light filament.

2. Separate the points of the gap at least two inches beyond the back-up spark desired.

3. Set the control as near as possible to the point where it will give the desired voltage and current.

4. Close the X-Ray switch.

5. Bring the points of the gap together until the spark over occurs.

The distance between the spark points at which the first sparking occurs indicates the true value of the voltage applied across the terminals of the tube in terms of "par-

allel spark gap between points." This true value is not obtained if the points of the gap are first set at the desired distance and the X-Ray switch afterwards closed. At the instant of closing the switch, a surge in voltage may occur which is much higher than that at which the tube is operating during the exposure.

MEASUREMENT OF VOLTAGE WITH TUBE RECTIFYING ITS OWN CURRENT

Upon operating a tube, which rectifies its own current, directly from the secondary of a transformer, the "inverse" voltage is always higher than the "useful" voltage. Consequently, the measurement of tube voltage by a parallel spark gap, used in the ordinary way, would in general be very misleading. The observed spark length would correspond to the "inverse" voltage and not to that which produces the X-Rays and hence determines their nature. A simple and very satisfactory method of dealing with this difficulty consists in connecting an alternating current voltmeter across the primary of the transformer and calibrating once for all this combination of transformer and volt meter. The calibration can be conveniently made with the help of a kenotron connected in series with the X-Ray tube. The two tubes should be so connected that current may pass through the X-Ray tube only in the proper direction. If now a spark-gap is connected across the X-Ray tube terminals, it measures the "useful" voltage. (This "useful" voltage is essentially what it would be if the kenotron were not in the circuit, for the voltage drop in a suitable kenotron is not more than one or two hundred volts and may, therefore, be neglected.) If the spark-gap

is then connected directly across the transformer terminals it measures the "inverse" voltage. The difference between the two will depend upon the load, and hence it is necessary that the calibration should be made for every load which it is desired to use with the tube. Unless appreciable changes take place in the wave form of the current supply, a single calibration suffices, and this may be made by the manufacturer of the transformer.

METER READINGS

The correct reading of all meters is the point at which the indicating needle comes to rest.

Focal Spot

The size of focal spot is of interest in radiography for the reason that with all other conditions the same, the tube having the smallest focal spot will give the sharpest definition in a radiograph.

The size and form of the focal spot may be determined by making pinhole-camera focal spot pictures of each tube. A convenient method of making this test is as follows:

Take a square sheet of lead, say ⅛ in. thick and of the right size to take the place usually occupied by the diaphragm in the tube stand. Make a conical depression in the center with a machinist's prick-punch, or other suitable tool. With a knife, remove the tiny prominence produced in this way on the back of the lead plate, and then, with a pin or small drill, open the hole to the desired size, say 0.02 in. in diameter. (If the hole is too large, the focal-spot picture will lack sharpness, and if it is too

small, the required time of exposure will be needlessly long.) Put the lead plate and the tube in place in the holder and lay the photographic plate on a table below. The size of the focal-spot-picture may be varied at will by raising or lowering the tube holder. *If it is to be of natural size, the distance from plate to pinhole should be exactly equal to that from pinhole to focal spot.*

It is a good plan to make two exposures, one of which is much longer than the other. The long exposure will then show the full extent of the focal spot, and the shorter one will show the distribution of energy over it.

With a hot cathode tube, the size of focal spot is always the same, regardless of the current and voltage employed.

PART III

X-RAY EQUIPMENT

THE INTERRUPTERLESS MACHINE

The purpose of this chapter is to present to the student and Chiropractor in as concise and practical a form as possible, the essential points bearing on the construction and operation of the accepted Standard X-Ray equipment i. e. The Interrupterless Type. While slight mention may be made of the design and operation of equipments of limited usefulness, the main endeavor will be centered on the accepted standards, as no Chiropractor engaged in a progressive pursuit of real value bearing nature will waste time and thought investigating inadequate apparatus. The definitions, illustrations and explanations will be practical in so far as it is possible to omit technicalities.

The revision of a text, following war conditions is somewhat complex, due to the fact that numerous styles, types and makes of apparatus, which were manufactured to meet special demands of a limited nature, have been pushed to the foreground and recommended to cover the entire Radiographical Field, which is far from the actual facts.

The Interrupterless type of equipment has stood the test of time and is conceded by all real authorities to be the acme in perfection of X-Ray work of the day.

To enable the student and Chiropractor to more readily understand some of the terms used in connection with

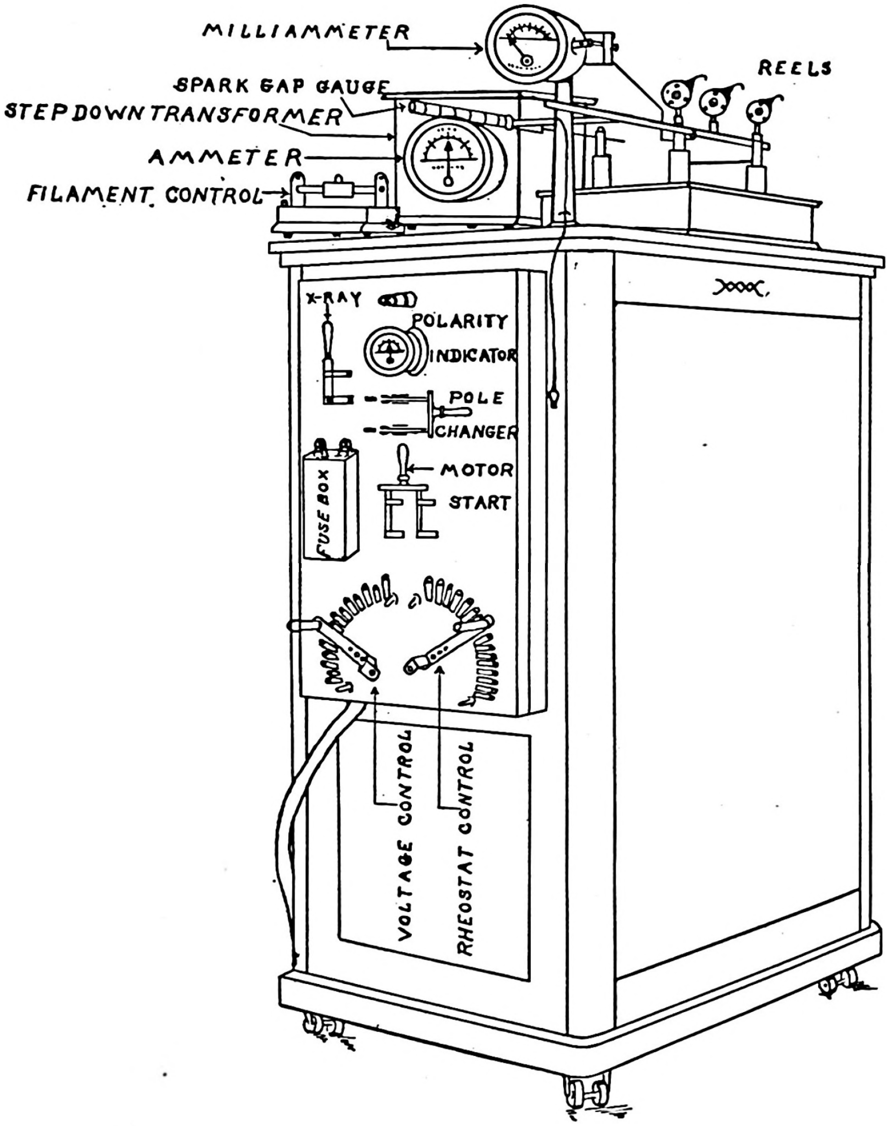


Figure 21—The Interrupterless Machine Showing Switch Board and Top of Machine Properly Named

the description of X-Ray apparatus, definitions of the more important electrical terms follow, which if the student will give a little time and thought in an endeavor to understand some of these terms, it will be found much easier to understand the descriptions which follow:

Actinic Ray—A ray of light or other form of radiant energy capable of producing chemical action.

Alternating Current — Currents whose directions are periodically reversed.

Ammeter or Amperemeter—Any form of galvanometer which is capable of measuring current strength in amperes.

Ampere—Unit of strength of the electric current, exerted by an electromotive force of one volt through a resistance of one ohm.

Anode—The positive pole of an electric battery or the electrode connected with it.

Anti-cathode of X-Ray tube—A plate of Tungsten platinum or other metal, supported inside an X-Ray tube upon which the cathodic stream impinges.

Automatic Cut Out or Switch — A device for automatically cutting off the current at any predetermined period of time by means of a time relay.

Blowing a Fuse—The melting of a wire by the passage of an electric current through it.

B. T. U.—Board of Trade unit—1000 watt-hours.

Calibrate—To determine the absolute values of scale divisions of an electrical instrument such as a Galvanometer, voltmeter,, wattmeter, etc.

Candle-Power—The intensity of light emitted by a luminous body estimated in standard candles.

Capacity of Condenser — The quality of electricity a condenser is capable of holding in coulombs when charged to a pressure of one volt.

Cathode—The negative pole of an electric battery, or the electrode connected with it.

Cathode Rays—Rays originating in a vacuum tube at the negative terminal, when a discharge of electricity is passed through the tube. They are not identical with the Roentgen rays, since they are deviable by a magnet and by refracting media, and are rapidly absorbed by opaque bodies and by the atmosphere.

Circuit—A term employed to denote the total electrical path of an installation.

Commutator, Current Reverser—An apparatus for reversing the direction of the current.

Condenser—An apparatus for storing a large amount of electricity.

Conductor—Any substance which conducts or possesses the power of conducting electricity.

Continuous Current (also called Direct) — A current whose direction is constant, as distinguished from alternating current.

Coulomb—Is that amount of electricity which is carried by an ampere flowing for one second past any given point in the circuit. There are 3,600 coulombs in one ampere-hour.

Current Strength—In a direct current circuit the quotient of the total electromotive force divided by the total resistance, or $C = \dfrac{E}{R}$

Current or Auto Transformer—A device for altering the voltage or pressure of a current, which may be either a step-up i.e. raises the pressure, or a step-down transformer, i.e. lowers the pressure.

Dielectric—Any material which offers high resistance to the passage of an electric current.

Difference of Potential—When electricity moves, or tends to move, from one point to another, there is said to be a difference of potential between them.

Discharge—The disruptive passage of electric current when opposite polarities approximate or a sudden equalization of potentials.

Dyne—The unit of force, i.e. the force which, if it acted for 1 second on a mass of 1 gramme, would, if the mass were previously at rest, give it a velocity of 1 centimetre per second.

Electric Efficienty—The ratio between the amount of current generated and the expenditure required to produce it.

Electroscope—An apparatus for detecting the presence of an electric charge or determining its polarity.

E. M. F. Electromotive force—The force exerted by an electrical charge.

Field (Magnetic)—The space about a magnet through which its influence is active.

Filtration of X-Rays—Placing in the path of the rays some medium such as aluminum or felt, in order to absorb some of the softer radiation.

Fluorescent (fluoroscopic) Screen — A screen covered with fluorescent material, which permits the visual examination of the human body by means of X-Rays.

Fluoroscopes—The phenomenon of fluorescence is the emission of visible light when X-Rays or cathode rays strike certain substances. In transforming the energy of X-Rays into light for the examination of radioscopic images, some substance must be used which fluoresces under the action of the rays. Roentgen originally used barium platino-cyanide, and this is very largely used now, although various other substances, such as potassium platino-cyanide and calcium tungstate are in use. Since the amount of light given out by a fluorescent screen is *small,* it is necessary to exclude all other forms of light either by carrying out the observations in a dark room or by enclosing the screen in some suitable observation chamber having an opening for the eyes. The chemicals used in preparing the fluorescent screen are applied to some support, this support in turn being fastened in the observation chamber. Various supports for the chemicals

such as cardboard vellum, blackened on one side, and rubber, have all been more or less used.

Fuse (Safety)—A soft metal wire interposed in a circuit, which will melt if a current too strong for safety passes through it.

Gap-Spark—The space between the terminals of two conductors.

Hard—Hard and soft are terms applied to X-Ray and other vacuum tubes; they refer to the relative completeness of the exhaustion therein of the retained air or residual gas. A hard tube has a higher resistance than a low or soft tube.

Henry—An electrical unit of inductance equal to the inductance of a circuit when the electromotive force induced in it equals 1 volt when the exciting circuit varies at the rate of 1 ampere per second.

Hot-Wire Meter—A meter whose readings are based on the expansion of a wire, due to an increase of temperature, by the passage through it of the current that is to be measured.

Hysteresis—A term applied to residual effects in the rapid magnetisation and demagnetisation of a soft iron core lying within a coil of insulated wire, through which an interrupted constant current is flowing.

Induced Current—That secondary current produced by induction. It flows in the opposite direction to the primary or inducing current when the latter is made, but in the same direction when it is broken.

Induction Coil—An apparatus consisting of two associated coils of insulated wire employed for the production of currents by mutual induction.

Insulator—A non-conductor or a bad conductor, e. g., glass, rubber, shellac.

Intensifying Screen—A surface coated with some fluorescing material, such as tungstate of calcium, placed in contact with the film side of the X-Ray plate; the time necessary for exposure is materially shortened.

Inverse Current—The current produced in the secondary of an induction coil on the making or completion of the circuit of the primary. Inverse currents flow in the opposite direction to the original current.

Joule—The amount of energy employed in maintaining a current of 1 ampere for 1 second against a resistance of 1 ohm.—10,000,000 ergs.

Kilowatt—1,000 watts.

Micro-Farad—Practical unit of capacity.

Milliampere—1/1000 of an ampere.

Milliamperemeter—An instrument for recording the strength of a current passing in fractions of an ampere.

Ohm—Practical unit of electrical resistance. It was decided (Paris Congress, 1884) that the legal ohm is the resistance offered by a column of mercury 106 cm. high, 1 square mm. in cross section, having about the resistance of 100 metres of telegraph wire.

Ohm's Law—The strength of the current varies directly as the E. M. F. and inversely as the resistance of the circuit, or the current expressed in amperes is equal to the E. M. F. expressed in volts divided by the resistance expressed in ohms: $C = \frac{E}{R}$

The law was enunciated by Dr. G. S. Ohm, and is used for showing the relation between Electromotive Force, Resistance and Current.

Oscilloscope—A vacuum tube constructed so as to show whether a current is unidirectional or oscillatory, and in the latter case roughly in which direction the greater quantity of current is flowing.

Pole Tester—Any device for readily determining the polarity of the current, e. g., wet blue litmus paper, will turn red in contact with the positive pole from a galvanic battery. The red spot will become blue again on the application of the negative pole, or when the end tips are placed in water and a galvanic current is turned on, bubbles of hydrogen will rise from the negative side, while the positive tip will become blackened.

Potential-potentia, power, ready to act, but not yet acting—It is the condition of electrical tension of a body. This term holds the same relation to electricity that the term level does to gravity; just as water at a higher level tends to move to a point of lower level, so does the accumulation of electric energy, at that point in the circuit at which it is present in excess over any other point in the

circuit, tends to seek that point in the circuit at which it is lowest, so that electrical equilibrium may be restored.

Ray, Rontgen or X-Rays emitted from the source of radiant energy excited by a discharge of electricity within a vacuum tube, not deviable by a magnet or refracting medium, they pass through opaque bodies, cause certain substances to fluoresce, affect a photographic plate like light rays, and they have peculiar effects upon living tissue, normal and pathological.

Rectified—An apparatus which is used to transform an alternating current into what is practically a unidirectional current. There are several kinds of rectifiers, the simplest of which is the "aluminium cell."

Resistance—(a) that which opposes the current flow.

(b) The ratio of E. M. F. to the current strength. $C = \frac{E}{R}$

Rheostat—An instrument for regulating the resistance of an electric current.

Rotary Converter—A machine similar in design to an ordinary continuous current generator, but provided with slip rings, connected to suitable points in the armature winding.

Sabouraud's Pastilles—Pastilles of light green color, called by Sabouraud tint A, which turned to an orange color, called by Sabouraud tint B, on being exposed to X-Rays, thus measuring the dose.

Self Induction—Induction produced in a circuit by the induction of a current on itself at the make or break of the current therein.

Supply, Unit of—Board of Trade unit.

Unit Megohm—1,000,000 ohms.

Unit Micro-Farad—1/1,000,000 farad.

Unit Micro-volt—1/1,000,000 volt.

Unit Milliampere—1/1,000 ampere.

Vacuum Tube—Glass tubes or bulbs from which nearly all traces of gas have been removed.

Volt—The practical unit of E. M. F. An E. M. F. which would cause a current of 1 ampere to flow through a resistance of 1 ohm.

Voltmeter—An instrument for measuring difference of potential.

Watt—Is a volt-ampere, or unit of electrical force.

Zero Potential—The earth's potential.

On page 112 of this book will be found a schematic sketch wherein all parts of the machine are named, which will enable the student to more readily understand the different parts of the mechanism in connection with the Interrupterless.

The Interrupterless type of equipment has for description the following important parts and a non-technical explanation will follow each part named:

TRANSFORMER

The purpose of the Transformer is to raise the potential or voltage from 110-220, at which voltage the circuit enters the building, to the required voltage for X-Ray tube operation. This will vary with the size and type of equipment, but usually will approximate from 60,000 to 100,000 volts or over.

The design of the transformer is extremely important, not from point of capacity and efficiency, but from point of maintained capacity under actual operation. If, for instance, the transformer maintained maximum voltage at practically no load, but showed a decided drop in potential or voltage under loaded condition, this would decrease the penetration of the X-Rays, because of the decreased voltage at the tube terminals. Transformers for stepping up low tension alternating current should be of the closed core type, i. e., the magnetic circuit is not broken by an air gap. In other words, the core of the transformer should be continuous and of a rectangular shape. The material used in building up the core should be special transformer steel and rigidly clamped so there will be no vibration or chattering of any part of the core, due to magnetic influence under actual operation. The part of the core upon which the primary winding is placed should be thoroughly insulated, and in placing the secondary winding, which is the high tension or high voltage winding, the very best insulating material should be used, such as macanite, which will separate and insulate the primary from the secondary winding. A transformer said to have 110,000 volts will produce a ten-inch flame discharge across its terminals. The following example will give you some idea of the design

of a transformer and the number of turns of wire required for a certain given voltage.

Assuming we have a secondary with 55,000 turns of wire and we wish to produce a ten-inch spark. To produce this spark requires 110,000 volts. The number of turns of wire for the primary will therefore have to be 55,000 divided by 110,000 multiplied by 220 equals 110 turns. A simple illustration of the above example would be, for instance—assume 1,000 turns on the transformer core on the secondary side with 100 turns on the primary side. If 100 volts were passed through the 100 turns side there would be impressed across the terminals of the 1,000 turn side 1,000 volts or approximately ten times the voltage of the 100 turn side. The voltage of a transformer can be calculated by the direct ratio of difference between its primary and secondary in number of turns, as for previous simple example—the number of turns on the one side was 100, while the number of turns on the secondary was 1,000. This then gives us a ratio of 10 to 1. If then 100 volts were passed through the 100 turn side you would have impressed upon the 1,000 turn side 10 times 100 or 1,000 volts. This essential feature then in connection with the transformer is the ability of same to retain approximate maximum voltage from zero load to maximum load. Also close proximity of the primary and secondary windings as well as a closed core. A secondary should be built in sections so that if repair is necessary, this can be done without practically destroying the entire winding.

Practically all transformers manufactured for X-Ray purposes are of the oil immersed type, while in former years the greater number were of the wax insulated type.

RHEOSTAT

The purpose of the rheostat is to control the amount of current which passes into or through the tube. In explanation of the working principles of the rheostat it can be likened to a valve in a water pipe—as the valve is opened in the pipe, less resistance is offered, and more water passes through. Likewise of the rheostat, the less resisting material you place in a circuit the easier the current can pass through, the rheostat being placed in one main lead passing to the transformer acting as a valve. If the rheostat handle is placed on the weakest button the current is forced to pass through a good many turns, made up in coil form of German silver or other resistance wire. Most manufacturers use a tinned iron wire, which offers a high resistance and naturally retards the current. If the rheostat is advanced, less of this resisting material is in this circuit. As an example—we might assume 1,000 feet of German silver wire inserted in the circuit between the transformer and the incoming leads. Suppose, as an example only, that this reduced the current 50 per cent and that this 1,000 feet was made up in ten coils spirally wound on asbestos insulating material in a vertical position in 100-foot lengths. Now if the circuit was forced to pass through the entire 1,000 feet, as has been stated before, as an example only, the circuit would be reduced 50 per cent. Now supposing by a moving contact, we could shorten this resistance wire 100 feet, the circuit would now pass through 900 feet only, the resistance of 900 feet not being as great as 1,000 feet, the current in your tube would increase slightly. Suppose you advance your rheostat to the fifth button, you have now cut out one-half or 500 feet of your resistance, and you will increase your current in your tube in proportion.

The essential features in the design of a rheostat are its ability to withstand a certain given current on a certain contact over a reasonable length of time without undue heating. Also the graduations should be uniform and not too irregular, so that the current in the tube will be increased gradually as the rheostat is advanced.

AUTO TRANSFORMER

The word Auto is a misnomer and has been the cause of considerable misunderstanding of this apparatus. It seems to be the general opinion of those who have not gone into the design and construction of an auto transformer, that this apparatus is a means through which you would be enabled to automatically maintain an absolute constant potential or voltage. This is not the fact, however. An auto transformer is in design practically the same as any other type of transformer, the main difference being that in the winding of same, taps are brought out at different points in the winding so as to permit our obtaining this voltage.

The auto transformer has been used in connection with electrical apparatus for a great many years, used extensively for starting purposes, where alternating current motors were being used, the object in this connection being practically the same, to have a means by which the voltage could be lowered in starting the apparatus and then gradually raising same to full potential when motor was running the full capacity. However, the essential difference in the working principles of the auto transformer, when used in connection with X-Ray apparatus, as compared to resistance control, is that by the use of the auto transformer the

operator is able to raise the voltage passing into the main high tension transformer, which in turn raises the voltage in the tube, but does not materially alter or affect the current or milliamps passing through tube. As an illustration of the advantage of the use of the auto transformer, the following example will suffice:

Suppose it was necessary to obtain a 6½ or 7-inch back up with a stated or given milliamps and after making the necessary adjustments on the filament control of your Coolidge tube you find you were unable to get the back up you desire. Now if you were using a resistance control type of machine you would find that if you would advance your rheostat, you would not only increase the voltage but you would also increase the milliamps considerably. This then is the point wherein the auto control is of considerable advantage, by leaving the rheostat on the contact that you choose you can advance the auto transformer, which will increase the potential or voltage so that you will be able to obtain a higher back up without materially increasing the milliamps. Another advantage of the auto control is the fact that when used in connection with a radiator tube and especially when a continuous exposure is made, the transformer being of a very rugged construction, it will withstand considerable abuse in the way of continuous operation, while if the same condition was imposed upon the rheostat control type of machine you would find there would be a slight heating of same. However, radiographically the auto transformer is not an absolute necessity, but with the addition of the auto transformer the apparatus is much more flexible.

MOTOR

The purpose of the motor in connection with the interrupterless machine is to revolve the mica disc. A properly designed motor is one which will keep in absolute step or synchronism with the incoming circuit. It is of course assumed on a 60 cycle system that the alternations will be 7,200 per minute, but it is a known electrical fact that it is impossible to maintain an absolute frequency, consequently the operation of the motor must be flexible, that is if the frequency or alternations rise or fall the motor will correspondingly rise and fall in speed and thereby keep in absolute step or synchronism with the circuit.

MICA DISC OR RECTIFYING COMMUTATOR

The purpose of the mica disc or rectifying commutator, which is attached to the motor shaft, is that of commutating or rectifying the alternating current which has been raised from 110 or 220 to 100,000 volts or more to a direct or uni-directional current. In other words, a current which is passing at all times in the same direction with no reversals.

The design of a rectifying commutator or mica disc is a very important one. It has been found, through experience, that it is possible to commutate too much, or in other words, make contact too long, in this way passing current into the tube which was objectionable. A disc which is properly designed should commutate or rectify approximately 15 per cent of the crest of the alternating wave, as anything more than 15 per cent approximately has a detrimental effect upon the penetration as well as

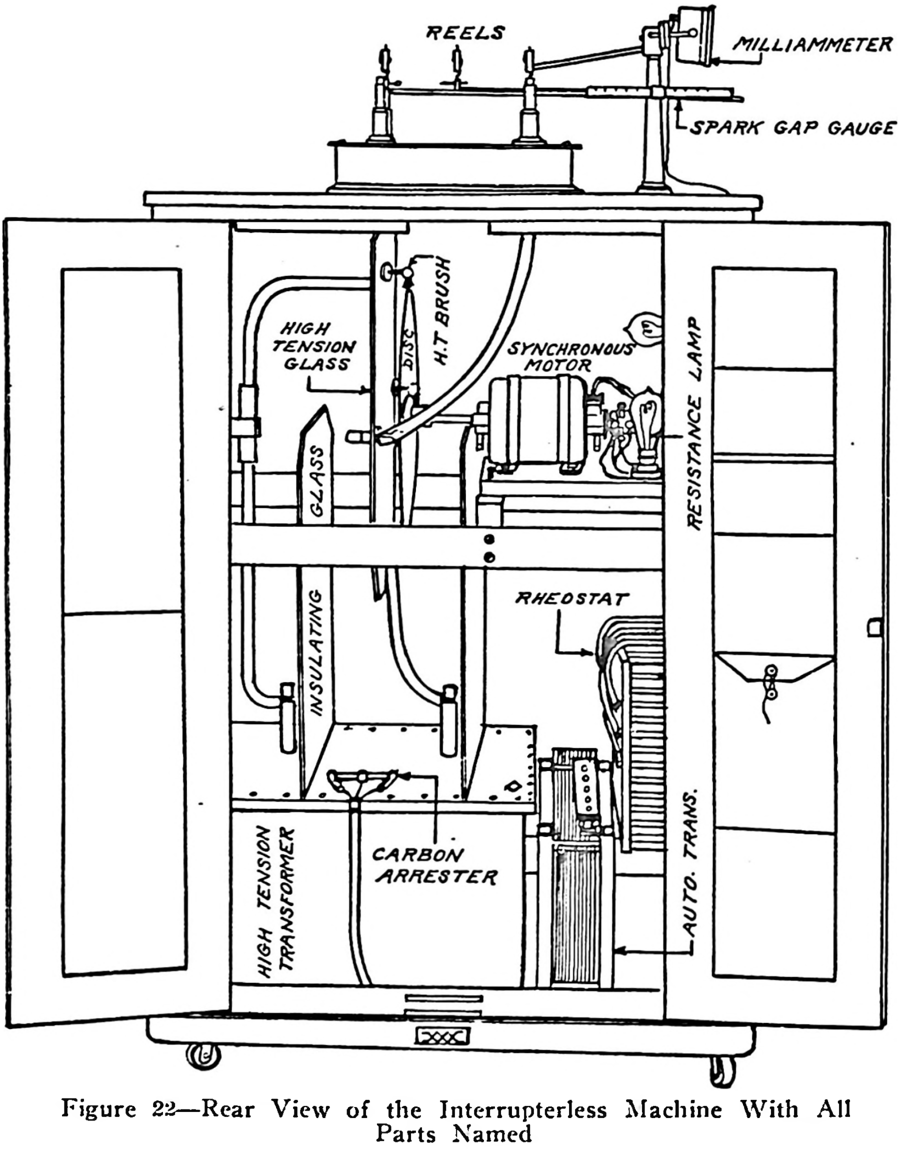


Figure 22—Rear View of the Interrupterless Machine With All Parts Named

the life of the tube. You will note in all interrupterless type of machines two connections passing from high voltage side of the transformer to the brush holders, which make contact with the revolving disc or commutator. You will also note two leads of wire passing from the brush holders, which make contact with the disc, to the terminals on the top of the machine, this making four contacts on the disc in all. Supposing we assume the left hand wire on the transformer, as you are looking into the case, to be negative, the right hand wire on the transformer to be positive. If the current maintained and would not reverse, such as is the case in direct current, it would not be necessary to reverse the leads to the top of the machine. Bear in mind this condition exists only for one seventy-two-hundredths part of a minute, for the next seventy-two-hundredths part of a minute the wire that was positive is now negative and the one that was negative is now positive, which would mean if the disc did not revolve and change contacts we would have a reversal of current to the top of the machine and into the tube. But during the time the current reversed, so also did the position of the disc, so now the connections which did exist one seventy-two-hundredth part of a minute have been reversed, so that the positive current is taken to the positive side of the machine, as well as the negative current being taken to the negative side of the machine. The next seventy-two hundredths part of a minute the change takes place again in the current. So also has the disc or commutator changed because of the rotation of the motor, and this operation is continuous, keeping the positive wire to the positive side of the machine when it is positive and keeping the negative wire to the negative side of the machine when it is negative, and

when the change takes place in the current, the disc also changes, reversing the connection and keeping the current in the proper direction at all times into the tube.

MILLI-AMMETER

The purpose of this instrument is to give an accurate measurement of the current passing through the X-Ray tube. The essential principles in its construction are approximately the same as any ordinary ammeter. The reason why the instrument on the X-Ray machine is called milli-ammeter is because it registers in one one thousandth of an ampere in place of one ampere, thereby giving you a finer gradation and a more accurate reading. It is of course essential that the instrument be accurate, and in practically all cases the instruments are thoroughly tested and found to be accurate and reliable before being placed on the equipment.

POLARITY INDICATOR

The purpose of the polarity indicator is to indicate the direction of the current and in the majority of cases is to place on the switch board that if the needle of the instrument swings to the right, the pole changer switch is closed to the right. If on the other hand the instrument needle swings to the left, the pole changer switch is closed to the left. Through the use of the polarity indicator, the operator is absolutely certain that the current will pass through the tube in the proper direction.

VACUUM REGULATOR

The purpose of the vacuum regulator is to have a means by which you can reduce the internal resistance of a gas tube, without leaving the machine. This is done by sliding a rod or pulling a movable contact over to the negative terminal on top of machine, in this way passing a current through the vacuum regulator and the reel and wire leading therefrom, to the regulating chamber on the X-Ray tube, the current then passing through the asbestos wick, which is filled with sodium hydrate or some other chemical which, when an electric spark or current is passed through gives off a gas. This gas reduces the resistance between the anode and the cathode terminals of the X-Ray tube, thereby decreasing its resistance as well as its penetration, or increasing the amount of current that can be passed through the tube at a given potential or voltage, as may be desired.

BACK-UP SPARK TESTS

The purpose of this test is to ascertain the penetration of the rays being generated in the tube at the time. The back-up test or spark gap, which has a movable rod wherein you can vary the distance between these points from approximately 2½ to 7 or 8 inches. In the majority of all osseous work, such as Spinography, experience has proven that a 5-inch back-up is best, while a tube of a 4-inch back-up would be much the best if you were taking a spinograph of a child. A tube of a 6-inch back-up would be best if you were taking a spinograph of a very heavy patient.

In testing a tube by the back-up method, first we should understand something of the "why" of the test, otherwise we are going into our work blindly. It seems to have been the opinion of some, until experience has taught them differently, that the spark gap has something to do with the operation of the machine proper, as well as the tube. Permit me to point out this is not true. The spark gap or back-up is a means by which the operator can ascertain the condition of the tube, whether it is too high, commonly spoken of as "hard," or whether the tube is too low, commonly spoken of as being "soft." The procedure which would be necessary for testing a tube follows: Assume we were taking a plate of an individual requiring a 5-inch back-up—advance your rheostat to a point which would give you approximately 25 M. A., set your spark gap at 5½ inches. See that your tube is properly connected, omitting the connection to the reducing chamber or auxiliary stem, close and open your X-Ray switch quickly. If the current jumps across or bridges the spark gap, return the rheostat to button No. 1. Push the reducing or vacuum regulator apparatus so that it makes contact with the negative lead of the machine connecting your middle lead with the auxiliary or reducing chamber of the tube. See that your rheostat handle is returned to button No. 1 and close and open your X-Ray switch very quickly; then disconnect your middle reel from the auxiliary stem or reducing chamber of the tube, pulling back your vacuum regulator apparatus on top of machine; return your rheostat to the former point, and test again for gap. See that your spark gap is set at 5½ and close and open your X-Ray switch again quickly. If it still jumps across, repeat the same procedure, which has been explained. After doing

same, disconnect your middle reel, return your vacuum regulator apparatus to its proper position, advancing the rheostat to the former point and again close and open your X-Ray switch quickly. Now if the current does not jump across or bridge the spark gap move the spark gap one-half inch closer to see that you have not reduced the tube too much. Now if it bridges the gap or back-up at 5 inches and does not bridge the gap at 5½ inches, your tube now stands at a back-up of between 5 and 5½ inches. Before starting your exposure, you should open your spark gap half an inch greater distance than the actual jumping distance of the current, as tested, and proceed with your exposure as follows:

Suppose, as per milliampere exposure table, which will be found elsewhere, you find that a 200 milliampere second exposure was necessary, you would proceed as follows: Close your switch for one second, noting how much current is passing through the tube; then open the switch for a second or so to allow tube to cool; then close your switch again, noting the current, open again after one second and as per example as follows. Supposing 20 milliamperes were passing through the instrument, every second of time will be equivalent to 20 milliamperes, adding each consecutive second until the sum total is 200—which means 200 milliampere seconds. Test your machine and tube out thoroughly, when first installed, to be certain that the spark gap does not decrease rapidly while exposing, due to heating of the rheostat. If you find the regulation is such that the gap decreased, say from 5 inches to 4 or 4½, you will have to increase the total number of milliampere seconds from 20 to 40 per cent over that given in the table, or else start out with one-half inch greater gap than indicated in

the average exposure table. This is quite important, as many machines will not maintain the same spark gap throughout an 8 or 10-second exposure, especially heavy currents are used.

MILLI-AMPERE SECONDS (M. A. S.)

Milli-ampere seconds are obtained by multiplying the milliamps passing through the tube by the time in seconds the current is used. Example—Supposing one milli-ampere was passing through the tube for 200 seconds, either continuously or intermittently, the product of the seconds times the current would be 200 milli-ampere seconds. Another example—For instance, 20 M. A. was passing through the tube and this amount of current was used either continuously or intermittently for 10 seconds, the product would be 10 seconds times 20 M. A. or 200 M. A. S.

The point I wish to convey in connection with the M. A. S. exposure system is this: Do not get the idea that you must know the number of SECONDS required for an exposure, but you must know the number of M. A. S. or total amount of current that is necessary to produce a certain negative. All of this has been figured in table form, wherein you can compare the thickness of any part of the individual with the table, and find the required M. A. S. for the given thickness. Now it makes no difference as to the time that is consumed in the exposure, but the most important feature is the total amount of **current over a given time**; consequently in figuring your exposure be certain that you time your individual seconds correctly, and when the product of the current (in milliamperes) which is passing through the instrument, multiplied by the num-

ber of seconds equals the total M. A. S. required, per table found elsewhere, your exposure is completed.

An approximate accurate system of testing a tube as to its condition is to note the amount of current passing through the tube on rheostat button No. 1, using the low scale of the milliampere meter, if it has two scales. A tube of the proper vacuum will allow the passage of approximately 3.4 or 3.6 M. A. and a tube which takes this current on button No. 1 will be of the proper back-up when used with a current of 20 to 25 M. A. If when testing a tube in this way you find the tube will not take this amount of current, the tube should be reduced slightly and the test repeated. If the current is still under 3.4 to 3.6 on button No. 1 the tube is still too high, and should be reduced again. In other words, a tube which does not take from 3.4 to 3.6 M. A. on button No. 1 should be reduced until it does take this amount of current.

In the foregoing descriptions and explanations, no attempt has been made to cover each and every operation exhaustively, from a technical standpoint. In fact, the opposite has been done. Technicalities have been eliminated and only the actual necessary terms used in connection with the apparatus. It is practically impossible to give a set of instructions which will cover any and all X-Ray equipment, even though they be of the same type and of the same manufacture, because of the fact that switches, rheostats, regulating apparatus are differently placed and have a tendency to confuse the operator until by actual demonstration and operation they have found out what each and every part is and its purpose. If, however, even.

a small amount of information is gleaned from the foregoing, the writer will feel amply repaid for his endeavor.

DON'TS FOR INTERRUPTERLESS MACHINE

1. Don't connect middle reel to chemical reducer of tube except when reducing gas tube.

2. Don't have rheostat lever beyond first button when reducing gas tube.

3. Don't use tube for radiography of heavy parts if it takes more than 3 M. A. on first button.

4. Don't reduce tube so that it will take more than 3 M. A. or show cathode (violet) stream on first button.

5. Don't reduce tube unless it takes less than 3 M. A. on the first button for radiography.

6. Don't take radiography with heavy current without changing to high scale on meter.

7. Don't have negative wire to cathode closer than 5 inches from chemical reducer of tube (perpendicular distance).

8. Don't close "pole changer" switch unless polarity indicator indicates correctly.

9. Don't clean commutator or slip rings of synchronous motor or rotary converter with emery paper or cloth. Use fine sand paper only.

COOLIDGE TUBE TRANSFORMER

The Coolidge tube transformer is designed to change the voltage from 110 or 220 to approximately 12 volts. The purpose of this circuit is to enable the operator to obtain

a low voltage, which is used to light the filament on the inside of a Coolidge tube.

COOLIDGE FILAMENT CONTROL

Inserted in the circuit of the small Coolidge transformer is a control sometimes spoken of as a portable, because of the fact that it is made small and compact, and can be moved to different parts of the room with a very long cord attached, so that the operator would be enabled to vary the amount of current passing through the filament of the Coolidge tube without being near the machine. This is especially advantageous in connection with fluoroscopy. The control used in connection with the Coolidge transformer is a very small unit of resistance wire wound over an insulated iron core which acts both as resistance and impedence, allowing a very fine gradation in the change of amount of current which passes through the filament of the tube.

COOLIDGE FILAMENT AMMETER

An instrument in the 12-volt filament circuit of the Coolidge tube which records the amount of amperes passing through the filament in the tube.

It is convenient because of the fact that after the operator has found the proper amount of current to be passed through the filament for a given back-up, a notation can be made of same so that again when attempting to obtain the same back-up the amperage passing through the filament of the tube can be set at the same point, which will be approximately accurate, although it may be found

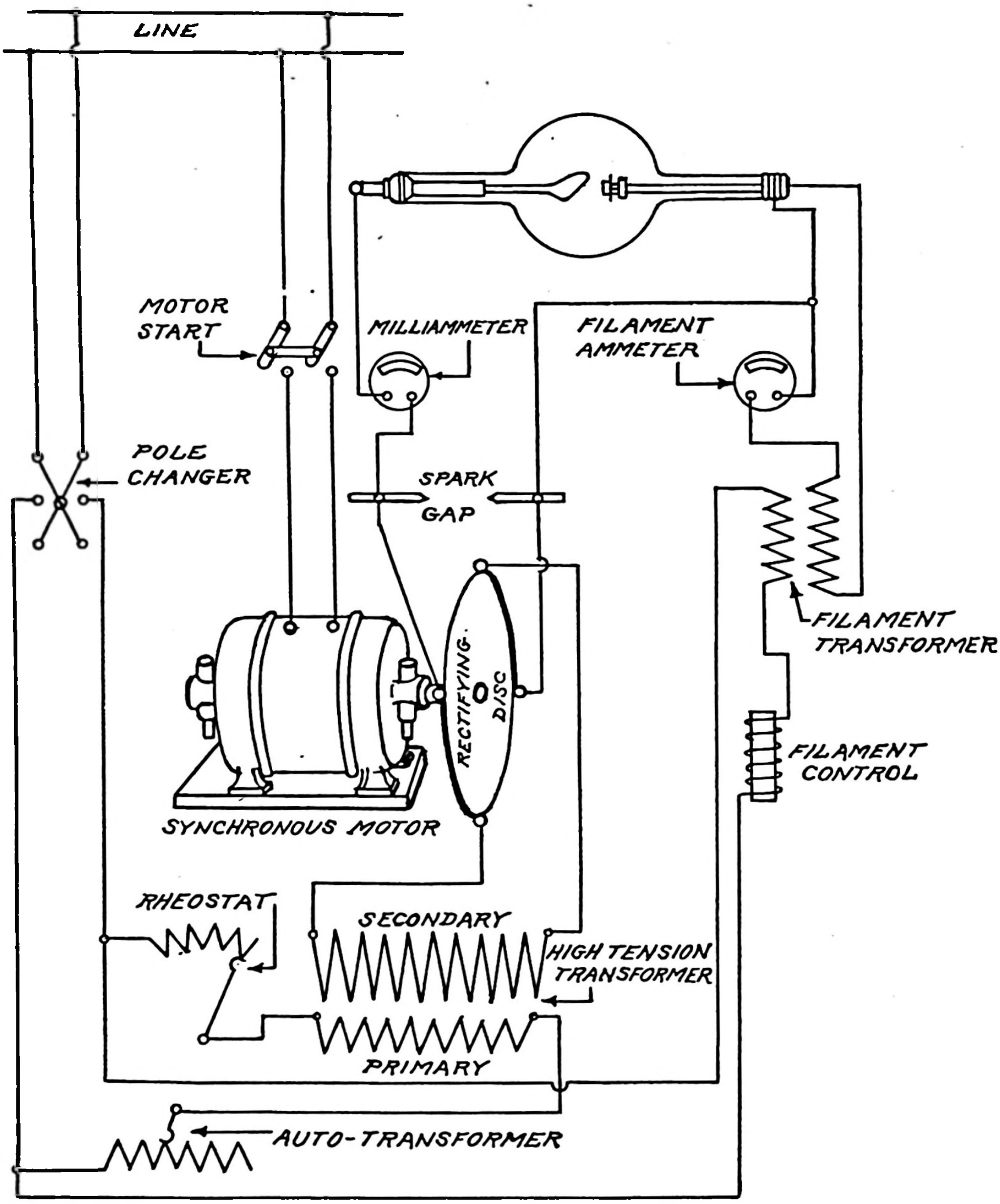


Figure 23—Illustrating the Flow of Current Through the Machine and X-Ray Tube

necessary to increase or decrease same slightly to obtain the identical back-up. This is due to the fact that slight voltage variations have taken place which necessitates a slight charge from the point at which it was found to produce a certain given back-up. It is not the purpose of the ammeter to give the operator an absolute infallible guide as to amount of current necessary for different back-ups, but it is a means of convenience and through the use of which a great deal of unnecessary testing is eliminated because, as before stated, after having found the approximate amount of current you should have for stated back-up, it is then a very simple matter to vary the current slightly in place of being forced each time to move all over this scale to obtain the back-up you desire.

In connection with the operation of Coolidge tubes of whatever type it is impossible to impress upon the operator the importance of maintaining a constant current passing through the tube throughout the entire exposure. Assume a given example, wherein you have obtained by testing a 5-inch back-up and 20 milliamps are passing through the tube. It is extremely important as you proceed with the exposure that one hand is kept on the filament control so that if the milliamps should increase or decrease, that you can compensate for this variation that is taking place by slightly increasing or decreasing the filament circuit of your Coolidge tube, which is done by the filament control. In other words, if you expect to produce plates or films with any degree of certainty, you must be absolutely in control of the filament current passing into the tube. If this is permitted to vary, the milliamps passing through the tube, through the high tension circuit will vary. This will mean that the back-up of the tube is varying anywhere

from ½ to 2 inches during the time the exposure is being made. For example: If the milliamperes increased to 25, it would be found that in place of having a 5-inch back-up that it had decreased approximately to a 3-inch back-up and your exposures no doubt would be a failure. It must then be borne in mind that if a check for a given milliamps and back-up is made, that the current passing through the tube must be maintained at constant point throughout the entire exposure, which is very easily done by watching the milliamper meter and increasing or decreasing slightly the filament current, as before mentioned.

MOTORLESS X-RAY APPARATUS

This type of apparatus consists of a step-up transformer with a maximum back-up of 5 inches, auto transformer giving various spark lengths from 3 to 5 inches, filament transformer, filament control and meter, milliammeter, line and X-Ray switch, single and duplex reel and measured spark gap.

When the line or service switch is closed, the tube filament lights up at the same time, the filament control is then adjusted and the back-up determined by the voltage control and back-up test.

Closing the X-Ray switch, the milliammeter indicates the current passing through the tube. The filament meter and milliammeter are both mounted on the switchboard and are not subject to any high potential.

The step-up transformer is of the oil insulated type and of such capacity to operate the 30 M. A. radiator type tube fully. Means are provided to regulate the voltage

entering the step-up transformer and maintaining a balanced circuit.

If it is desired to operate the apparatus for limited fluoroscopy, a foot switch can be attached conveniently to the control board.

The apparatus described in the foregoing meets the demand of those desiring to have an apparatus which will cover a limited portion of the X-Ray field.

It is claimed by some that this type of apparatus is of sufficient capacity to cover the entire radiographical field. The one point in connection with this type of apparatus which seems to carry considerable weight is the fact that it is motorless. By comparing what can be done with the two types of machines, namely, the motorless and interrupterless, the student will quickly grasp the difference between the two types of apparatus..

In connection with the operation of the motorless type, it will be well to bear in mind the fact that you are limited to the use of one type of tube only, the Radiator 10 and 30 M. A. This means, were you to attempt to do fluroscopical work, wherein it is necessary at times to use a back-up of 6½ to 7 inches, you would find your equipment would be absolutely worthless. This is also true in connection with making exposures of extremely heavy cases, wherein it will be found quite advantageous to be able to use a back-up of 5½ inches. While it is admitted that in making an exposure of an average case and even some heavy cases, a low back-up used in connection with intensifying screen gives by far the best detail. However, there are times when it taxes the capacity of an equipment to

penetrate the structures of extreme cases. As has been stated before, the fact that the equipment is motorless seems to carry considerable weight with the prospective purchaser, it not being generally known that if the operator desires—it is not necessary to use the motor in connection with the operation of the interrupterless type of machine, that same can be left out of the circuit—a radiator tube used, and you have a motorless as well as an interrupterless. In other words, with the interrupterless type of machine you would be able to use either 10 or 30 M. A. radiator, any one of the three universal or regular tubes, any and all types of gas and hydrogen tubes, as well as being able to use, as outlined above, the machine as a motorless apparatus. When these points are taken well into consideration, there is absolutely no comparison of the interrupterless as compared to the motorless, as with the interrupterless you have an equipment, which will meet the entire demands of the radiographical field, while with the motorless apparatus you are handicapped.

A point of considerable importance which must be taken into consideration in the purchase of X-Ray apparatus, especially of the interrupterless type, is that if you are looking for the maximum safety, you will not install a machine upon which will be found an auto transformer or voltage control only, which are synonymous, as an interrupterless equipment which does not include both a rheostat and auto control is considered quite dangerous, not alone to the operator, but also to the patient.

It is a known electrical fact that where anything in the form of a coil is used, there is considerable increase in voltage caused by the inductive kick when the circuit of

the coil is interrupted or broken, such as when the X-Ray switch is open. When there is no resistance unit in the circuit, there is no protection whatever in the way of retarding this peak of voltage which occurs at the time of a slight interruption of the circuit as well as when the X-Ray switch is opened.

The writer has conducted numerous tests on machines, equipments with rheostat and auto control, wherein demonstrations have been made which proved conclusively that even though the X-Ray switch be closed and the high tension circuit in operation, that the operator or the patient could come in contact with either of the high tension leads without any dangerous effect, while it is admitted that such a shock is far from being pleasant, yet it is not extremely dangerous. However, the writer does not suggest that the novice experiment along these lines.

Tests were also made with machines equipped with auto control only, wherein it was found that if contact was made with either of the high tension leads, it would be extremely dangerous because of the inductive effect of the winding of the auto transformer.

Those wishing to be in possession of the most efficient and safe apparatus will not be content with a machine wherein the control is an auto transformer only, but will insist on a machine of the rheostat control or if the auto transformer or voltage control is used, that the machine must also include a rheostat, in this way having an apparatus wherein safety for the operator and patient has been provided in so far as is humanly possible in the operation of high tension circuits.

The information recorded in the article which follows is given out by the Rockefeller Institute for Medical Research and is considered absolute authority. It might be well for the operator to reflect on this statement, so as to realize the full importance of the information which follows. If the operator or technician would study and thoroughly master this technique, then should occasion arise, wherein legal action was instituted in connection with the taking of plates, it would then be very easy for the doctor to prove conclusively that the technique used was not in error, and which he could very conveniently prove to the court was far below the maximum dose required to produce any effect whatsoever.

The spinographer or technician who is content with the mere mechanical procedure of exposing can never hope to become competent in his work. There is seemingly no excuse whatever for the operator of X-Ray apparatus who is proficient in the use of the technique of exposures, but unable to predetermine whether or not it would be safe to proceed with an exposure of a patient wherein several exposures have been made. There are several very important points in connection with the effect of X-Ray on the tissues of the body. One is the penetration of the tube. All statements to the contrary, it is a known fact that the higher the back-up or greater penetration of the ray, the less danger there is to the patient in ratio. This is due to the fact that the greater the penetration or higher the back-up of the tube, the less soft ray there is being given off, while a tube of a low back-up would be the reverse, and would be extremely dangerous to use, without the use of an aluminum filter.

Another very important point in connection with effect of exposure of patient is the skin distance, which means the distance from the center of the target to the surface of the patient's body, which will vary anywhere from 8 inches to 14 or 16 inches, depending upon the length of cone or compression cylinder, which is used in connection with the tube stand apparatus.

The following article which goes into detail in the description of the method mecessary to predetermine the effect of one or more exposures of the same section will be found very valuable and the technique in connection therewith, is so simple that anyone having very ordinary knowledge of mathematics will have no difficulty in being able to figure out the effect of any exposures. I wish to call your attetnion in particular to examples 7 and 8, wherein there is a difference of only 2 inches in skin distance in tube distance. The same exposure in milliamp seconds was given; tube distance was identical, back-up same, but the number of plates permissable in one case was 4, while in the other 6. It would never be found necessary for the technician or spinographer to make an exposure or exposures, which would approximate one skin unit, or the amount which would be a maximum limit, under practically no circumstances would it be necessary to approach within 60 per cent of the amount necessary to be equal to one skin unit.

EFFECT OF X-RAY ON THE TISSUE

(From the Rockefeller Institute for Medical Research, New York)

The maximum number of exposures in a given case that can be made without producing a roentgen-ray burn, an erythema or a temporary or permanent alopecia can be obtained by the formula used for determining unfiltered dosage. The principle of this formula is based upon the fact that roentgen-ray burns, alopecia, etc., depend entirely on the quantity of a roentgen-ray reaching the skin, as pointed out by Remer and Witherbee in June, 1917.—Am. Jour. Roentgenol, June, 1917; also a more recent article published in Arch. Dermatol. and Syphilol, May, 1920.

The standard formula for one skin unit, or the amount used for treatment of ringworm of the scalp, is expressed as follows:

$$\frac{\text{3sp. gr.x3 ma.x4 min.}}{\text{8-inch distance 8-inch distance}} = 9/16 = 1 \text{ skin unit}$$

To illustrate the practical application of the above fraction, 9/16, let us take the factors given in the Army Manual for the various exposures, then estimate the skin distance from the target of the tube in each position of a patient whose measurements are a little above the average, substituting the skin distance in each case for the plate distance. This formula, with the skin distance substituted for the plate distance for an A. P. head, would be:

$$\frac{\text{5sp. gr.x40 ma.x1/5 of a minute}}{\text{12-inch distance 12-inch distance}}$$

instead of 20-inch plate distance. This reduced to a simple fraction equals:

$$\frac{5\times\overset{\overset{5}{\cancel{10}}}{\cancel{40}}\times\overset{1}{\cancel{5}}}{\underset{3}{\cancel{12}}\times\underset{6}{\cancel{12}}}=5/18$$

If the fraction 5/18 or its formula represents the dose for each exposure, then the number of plates taken to produce a temporary alopecia or 1 skin unit, would be the number of times 5/18 is contained in 9/16:

$$9/16\div5/18=9/\underset{8}{\cancel{16}}\times\overset{9}{\cancel{18}}/5=2\ 1/40 \text{ plates.}$$

Therefore:

	B. U. or Sp. gr.	MA.	Time Minutes	Plate distance Inches	Skin distance Inches	Number of plates
1—Head A. P.	5	40	1/5	20	12	2
2—Head Lat.	5	40	1/10	20	14	5
3—Neck	5	40	1/20	20	16	14
4—Shoulder	5	40	7/120	20	10	5
5—Elbow	5	40	1/40	20	17	34
6—Wrist	5	40	1/60	20	18	54
7—Kidney	5	40	1/15	20	10	4
8—Bladder	5	40	1/15	20	12	6
9—Hip-joint	5	40	1/12	20	12	5
10—Pelvis	5	40	1/12	20	12	5
11—Knee	5	40	1/30	20	15	19
12—Ankle	5	40	1/40	20	17	34
13—Lumbar Spine	..5	40	1/10	20	10	4
14—Teeth (slow film)	5	40	1/15	20	18	13
15—Teeth (fast film)	5	40	1/40	20	18	36
16—Chest	5	40	1/15	28	16	11

The importance of the distance of the skin from the target of the tube is well illustrated in the list of number of plates, especially in the case of kidney and bladder exposures. Here the only change in the four factors is distance. The difference in distance is 2 inches, which makes a difference of two in the number of plates. This should make one exceedingly cautious when dealing with excessively large individuals whose thickness demands the maximum exposure.

For one who is not using the army factors and who has inadvertently used the wrong factors in a given case to obtain the best results, and wishes to repeat the procedure, it is a simple matter to determine the dosage the skin has already received and then decide whether it would be safe to repeat or postpone the operation for a time.

In taking a series of plates or films, overlapping of the areas exposed must be considered even though the factors are correct and properly maintained throughout each exposure.

From the foregoing list of number of plates it is obvious that the head, kidney, bladder, pelvis and lumbar spine are the ones that require the larger doses to obtain results. If a case of this kind is passed on from one roentgen-ray laboratory to another, in a comparatively short time, and standard exposures made in each place, a roentgen-ray burn may occur. Roentgenologists and especially those who specialize in the branches in which these large doses are required to obtain good plates, would appreciate a complete roentgen-ray history as well as clinical history of these cases. By a complete roentgen-ray history is meant the time the plates were taken, the position of the patient,

the factors used in making the exposures and the date of the last examination. . With these data the roentgenologist could determine at once how soon it would be safe to proceed with his examination, instead of waiting three or four weeks from the date of the last exposure in order to avoid either adding to an already produced burn or adding enough more to produce one that otherwise would be a safe and sane exposure.

Erythema appears in from ten to fourteen days, so that at the end of three weeks one is safe in concluding if the skin appears normal, that the exposure the patient has had was not sufficient to produce an erythema. But the dose may have been of such intensity that by adding the large amount necessary for the second examination may induce an alopecia or erythema by the combined exposures. If an erythema or temporary alopecia has occurred during the third week after the first examination it would seem advisable to wait at least six weeks from the date of the last exposure.

From a medicolegal standpoint it would seem assured that the defendant would be in a much better position to defend himself if he knew his factors and the valuation of the same in determining the cause of roentgen-ray burn.

The army factors with an interrupterless machine and a Coolidge radiator type tube whose maximum working factors are 5 inch gap and 30 M. A. would mean a change from 40 Ma. to 30 ma. and a proportionate increase in the time of the exposure. For example, the factors given for an A. P. Head are 5-inch gap, 40 ma. at 20-inch distance, with 12 seconds' time. To compensate for the one-quarter decrease in milliameter, the time given in army formula (12

seconds) would equal three-quarters. One-fourth would be 4 seconds, and four-fourths 16 seconds, or the time necessary to produce the same effect on the plate.

The principle involved in the adaptation of the above mentioned radiator tube to the army formula may be illustrated by Prof. J. S. Shearer's roentgenographic formula:

$$\frac{40\text{ ma.}\times(5\text{ K V})^2\times 1/5\text{ minute}}{(20\text{ inch distance})\quad 2} = \frac{\overset{\overset{2}{\cancel{10}}}{\cancel{40}}\times\cancel{5}\times\cancel{5}\times\overset{1}{\cancel{5}}}{\underset{\cancel{4}}{\cancel{20}}\text{x}\underset{\underset{2}{\cancel{4}}}{\cancel{20}}} = \frac{1}{2}$$

$$\frac{30\text{ ma.}\times(5\text{ K V})^2\times\text{time}}{(20\text{-inch distance})^2} = \frac{\overset{15}{\cancel{30}}\times\cancel{5}\times\cancel{5}\times T}{\underset{4_2}{\cancel{20}}\times\underset{4}{\cancel{20}}} = \frac{15}{8}$$

$$\tfrac{1}{2}\div 15/8 = 1/\cancel{2}\times\overset{\cancel{4}}{\cancel{8}}/15 = 4/15\text{ minutes} = 16\text{ seconds.}$$

By interposing ½ MM. aluminum filter, three times the number of plates may be made, and with 1 mm. aluminum filter six times the number of plates without danger to the patient. This is based on the time necessary to produce 2½ skin units of filtered roentgen-ray, using ½ and 1 mm. aluminum filter with the army factors and skin distance instead of plate distance. From the regular formula 12 seconds is the time for one plate of an A. P. Head. With a skin distance of 12 inches 2 1/40 plates can be taken without a filter. The time necessary to produce 1½ filtered skin units, which corresponds to ¾ unit unfiltered biologically, using ½ mm. al. = about 1 minute, 12 seconds with 1 mm.

al = about 2 minutes. Therefore, 1 minute and 12 seconds = 72 seconds ÷ 12 seconds = 6 plates, or three times the number allowed without ½ mm. al. filter 2 minutes = 120 seconds ÷ 12 seconds = 10 plates, or 5 times the number indicated without 1 mm. al. filter.

PROTECTION OF THE PATIENT

The protection of both patient and operator is a very important part of X-Ray work, and everything written along these lines should be carefully considered by any one using the X-Rays. Patients can be burned with the X-Ray today as they were during the early stages of its development.

In those days the pioneers who were working with the X-Rays knew very little of the dangers connected with them and many received X-Ray burns, some to the extent of losing their lives; sacrificing themselves to develop this great and good work that you and I might profit thereby.

This is true of all great discoveries and undoubtedly will always be so. We only have to look back over the field of science and art to see the many who have given up all they possessed that they might improve upon the work to help future generations.

Through the experiences of these men the X-Ray world of today has taken heed and profited by such experience. Today, we know what to use and how to use it to protect ourselves and patients from many of the dangers incident to the X-Rays.

We do not hear of patients or operators being burned with the X-Ray today as we did years ago, all because of

the precautionary measures that have been applied. It is true that a few received X-Ray burns, but when you read or hear of it you can form your own conclusion, that it was carelessness on someone's part, and usually this carelessness is due to the operator, as he is supposed to know whether or not his equipment is in good working order. Sometimes circumstances are such that you are unable to determine such cases by observation and it is impossible for the operator to take precaution against the danger. However, ordinarily there are not so many precautions, but what every operator should remember them. Read them carefully and always follow them that you may not be one of the careless few.

Before making an exposure, the operator should test the tube to see that it is in good working condition. By testing the tube we know whether or not it has proper penetration for the required exposure. It is true of all gas tubes that they may change in vacuum, become accidentally reduced or punctured, which should all be known before taking the picture. This is found by testing the tube and this process should be completed before placing the patient on the table. While making the exposure, the operator should watch the milli-ampere meter, for any variation in the amount tested for, thus designating a variation in the resistance of the tube, whether it be a gas tube or a Coolidge tube. In this way he may govern the penetration of his tube more accurately.

Do not expose a patient to more than 1200 milli-ampere seconds at one time, as it is never necessary to use a heavier exposure than that for a spinograph taken from the anterior to the posterior, if the proper technic is used. It is best

for the operator to avoid making successive exposures which are heavy, at less than three- or four-day intervals, as it is the accumulative effect of these X-Rays that may produce a burn. There would be danger of an over-exposure if more than 1200 milli-ampere seconds were used at one time.

Keep patient's hands away from the metal parts of the table so as to protect them from feeling the static electricity. When the hands loosely come in contact with any metal parts they will feel it, although this may be stopped by placing their hands firmly against the cylinder. It is well to have a wire attached to the tube stand or table connected with some piping that is grounded. This will take care of the static electricity. Should the patient suddenly feel the static current he may jump or move out of position, which would blur and spoil the plate. This static electricity produces no ill effects, but frightens the patient. This we must try to avoid, as we must make the patient feel at ease and confident of our ability to protect them from discomfort and apprehended dangers.

Static electricity manifests itself in three ways: as a breeze blowing over the part being exposed; in the form of a weight being pressed upon the region exposed, or a prickling or tingling sensation.

There are other electrical dangers to patients and visitors, that should at all times be considered by the careful operator. The law of common practice is to see that there are no wires coming in close proximity to the patient when being exposed or to any one assisting the operator in holding the patient quiet upon the table. It must be remembered that these wires are carrying a heavy voltage and should the patient or any one assisting come in con-

tact with them, it may mean a damage suit for the practitioner. It is advisable to use over-head wiring so that there is always plenty of room to walk and work underneath the same without any danger.

X-RAY BURNS

X-Ray burns may be produced by over-exposing the patient or by using a soft tube. A soft tube means one producing rays with low penetrating qualities. The rays do not penetrate the heavier parts of the body rapidly and as a result there is an accumulative effect from the non-penetrative X-Rays and finally a burn is produced unless the intensifying screen is being employed, the rays passing through the body do not burn unless it is an over-exposure. Those not passing through, or very soft rays, are the ones that may result seriously to the patient.

No matter how high the degree of penetration is, there is always a certain number of soft rays being given off, and it is the accumulating effect of these rays that finally produces the burn.

Aluminum filters are used between the tube and the patient to decrease the effect of the soft rays. This aluminum filter should always be two or three inches away from the glass of the tube, as there is danger of puncturing the tube should it be closer. A thin piece of wood or leather will also answer the purpose but not so well as aluminum.

Over-exposures with a high tube or a soft tube will produce the following conditions, in some people: 1. Sterility. 2. Roentgen Dermatitis or Erythemia. 3. Decrease in White Corpuscles. 4. Severe burn which acts similar to

that of a cancer, causing sluffing of tissue, etc. Anyone of these conditions mentioned are apt to be produced when using the X-Ray for treatment purposes. There are few people being burned by the X-Rays when having an exposure for X-Ray picture, as the exposure is not long enough to produce an X-Ray burn or any one of these conditions mentioned unless there is 1200 milli-ampere seconds or over given.

PROTECTION OF THE OPERATOR

The operator must always bear in mind that he must protect himself as well as his patient. He is working with the X-Rays day after day and for this reason is more liable to its effects than the patient. He can protect himself by using the following precautionary methods, never allowing himself to become careless:

The author has worked with the X-Rays for a number of years without any ill effects whatsoever, all because he has used these following precautionary measures has been careful to the fullest extent.

The operator doing much of this work should always work behind a lead screen or cabinet, as lead is opaque to the X-Rays and will stop all secondary rays. It is the secondary rays that are harmful to anyone continually exposed to them and a lead screen or cabinet will eliminate this form of danger.

Almost all tube stands are equipped with a lead glass bowl. This acts as a receptacle for the tube, as well as being opaque to the X-Rays, helping to confine the secondary rays therein. Having it however, is not enough if

used without a lead screen, as the lead composition is not sufficient to stop all the secondary rays. It is found that some individuals are more susceptible to the effects of the X-Rays than others, especially those of light complexion.

There are operators who have started using only a lead glass bowl for protection, only to find, sooner or later, that they must add to their equipment a lead screen or lead-lined cabinet. It is well to have a rubber mat to stand upon while using the machine, as it helps to break any shock should the operator accidentally come in contact with any of the metal parts of the switchboard. It is safer to use one hand, only, in manipulating the switches.

The operator should see to it that the target of the tube is always pointed away from the switchboard, so that all direct rays generated within the tube are focused away from him and not towards him, even though he is behind a lead screen.

The object of working behind a lead screen is to prevent the X-Rays from having an accumulative effect in the body. The X-Rays penetrate some sixty to seventy feet away from the tube and when a sufficient amount of them have accumulated, they produce anemia or sterility, having a weakened effect upon the body. Some operators, however, are apparently not susceptible to them even after years of daily use.

PART IV

INTENSIFYING SCREENS

In the beginning, the use of X-Rays was limited to the location and reduction of bone fractures, foreign objects and osseous or organic formations which resisted the penetration of the rays. This situation was due to a variety of causes, among which were the lack of experience in determining proper voltages; distances and lengths of exposures; the inability to secure a photographic effectiveness greater than 1 per cent of the intensity of the rays; the lack of suitable actinic convertors; sufficiently sensitive and rapid emulsions for photographic plates and suitable measuring devices.

Gradually, as many minds were applied to the problems of Roentgenology, methods were found for saving some of this lost energy and changing it into actinic rays which would increase the intensity of the visible image and the clarity and needed contrast of photographs.

X-RAY PHOTOGRAPHS

Ordinary photographs, which the camera user takes, reproduce the images of landscapes, people, or objects upon which ordinary white light rays fall.

X-Ray photographs are not produced in this way at all. They are actual shadowgraphs produced by a different sort of ray coming through the object being photographed from behind it.

The location of the source of light behind the object necessitates care in positioning to prevent distortion; the proper voltage and fast, contrasty emulsion on the films or plates to prevent indistinct or hazy images.

To secure this contrast, it is especially important that as much of the X-Rays as possible be converted into actinic light rays, which will act upon the emulsion. It follows that suitable screens are absolutely necessary.

WHY GOOD SCREENS ARE NECESSARY

In modern surgical practice, the need for an operation is frequently determined by X-Ray photographs. There have been many cases—notably among abdominal operations—where the decision on whether or not to operate rested on the clarity of the image revealed by the X-Ray photograph.

Correct diagnosis in surgical and in many medicinal cases requires the use of the best screens available in order that a clear record may be obtained of the affected parts.

ANOTHER REASON

When unintensified Roentgen-rays strike a photographic plate or film, **less than one per cent** of them act on the emulsion to produce an image. To secure a clearer image or show greater detail, or secure speedier exposure, it is therefore necessary to utilize some of this 99 per cent of wasted energy.

It has long been known that certain chemicals have fluorescent properties, i.e., of absorbing X-Rays and so

changing them that they are emitted as actinic light. At first, screens treated with these chemicals were used only in hand fluoroscopes. Later, expermients were made with screens in taking X-Ray photographs, and it was found that much more contrasty negatives were obtained; that sharper detail was secured and that the time of exposure was shortened. Further developments resulted in commercial intensifying screens which were quite successful. The time required for exposure was shortened without reducing the quality of the results. Quite the contrary, exhaustive tests have proved that, when proper screens are used, better photographs are obtained.

With modern screens of extra good quality, the effectiveness is increased 600 per cent, even where but one screen is used.

WHAT CONSTITUTES A GOOD INTENSIFYING SCREEN?

It is impossible to tell the quality of a screen by merely looking at it, although some of its good points will be apparent in its glossiness or surface texture.

Commercial intensifying screens are made of specially prepared cardboard coated with a smooth layer of clear white chemical compound having a base of Calcium Tungstate.

The exact composition of the compound is important, because an inferior quality of its ingredients will result in excessive phosphorescence. But even more important than the basic purity of the chemicals, is the process of treatment and preparation. Just as two cooks may use exactly

the same quality and quantity of the identical ingredients and produce, one, an excellent cake, and the other, a poor one, so can an intensifying screen of low power be made from exactly the same materials as are found in the best screen obtainable.

The salt in the emulsion must be "tuned" to the film or plate to secure truly good actinic conversions of light rays.

Photometric tests by a large manufacturer of photographic materials showed that the light emitted by Intensifying Screens is the most effective light known for photographic work.

Mottling and graininess are the most frequent faults of intensifying screens. It is not possible to absolutely overcome graininess since the fluorescent coating is made up of minute particles held together by a binding agent, but the correct preparation of this coating and care in the selection and treatment of the binder will reduce the effect of this graininess to an almost neglectable factor.

Intensifying screens are now so carefully made that there is no graininess nor mottling apparent.

Performance is the final test of quality in an intensifying screen.

A good screen must be coated with a chemical combination of great permanence and stability so that the screen may last indefinitely and be unaffected by heat, light or dampness. The developments of several years of experimenting have, at last, brought out a screen which needs no "airing" at frequent intervals for some weeks, as was necessary in earlier types.

Not only is the coating of some X-Ray Intensifying Screens of so fine a texture that there is virtually no graininess nor mottling, but the composition of the emulsion is not only chemically, but physically correct also, and it is of such permanence that the screens will last indefinitely with reasonable care. They require no seasoning whatever, and are unaffected by heat, light or dampness.

DIRECTIONS FOR USE OF INTENSIFYING SCREENS

The object of the Intensifying Screen is to assist the actions of the X-Rays in exposing a negative, reducing the time of exposure. The Intensifying Screen is a card-board coated on one side with a chemical which fluoresces under the action of the X-Rays, and the actinic light given out assists in exposing the negative. There are two methods of using Intensifying Screen: one method with the film or plate and the single screen, and the other, with two screens and the duplitized film, which is known as double screen technic.

SINGLE SCREEN TECHNIC

Each Intensifying Screen should be mounted in its own plate-holder or cassette. This serves two purposes. The first and most important is, that it gives the necessary contact between the negative and the screen. It is very essential that intimate contact be maintained between the negative and the screen owing to the fact that the light given out by the screen follows the laws of ordinary light and the intensity of it is inversely proportional to the square of the distance. The light given out by the Intensifying

Screen is not very strong and therefore any slight distance between the plate and the screen will cause a poor picture. The second advantage of the cassette is that it offers a good protection for the Intensifying Screen.

The Intensifying Screen is mounted on the lid of the cassette, **emulsion side out**, and when loading the sensitive emulsion of the negative should be next to the sensitive side of the screen. When taking radiographs, place the cassette under the patient so that the rays pass through the smooth aluminum face of the cassette, then through the plate, striking the screen last. The exposure with an Intensifying Screen will be reduced about one-fifth the usual time required to make an unassisted negative. In single screen technic a tube of relatively low penetration should be used.

DOUBLE SCREEN TECHNIC

This practice consists of using two Intensifying Screens and a duplitized film. The duplitized film has a photographic emulsion on each side and when using two screens there is a screen against each surface of the film.

When mounting double screens in a cassette a thick screen is mounted against the lid of the cassette and a thin screen is mounted in the bottom of the cassette and when loading the duplitized film is placed between the screens. After the cassette is loaded, place it under the patient with the smooth aluminum side up so that the rays will pass through the **thin** screen first, then the film, and last, the thick screen. **Never** use plates with double screens.

The advantage of double screen technic is greater speed, for this method is nearly twice as fast as the single

screen and plate, and, furthermore, better contrasts are obtained. There is another advantage and that is that a tube of higher penetration may be used without affecting the quality of the negative.

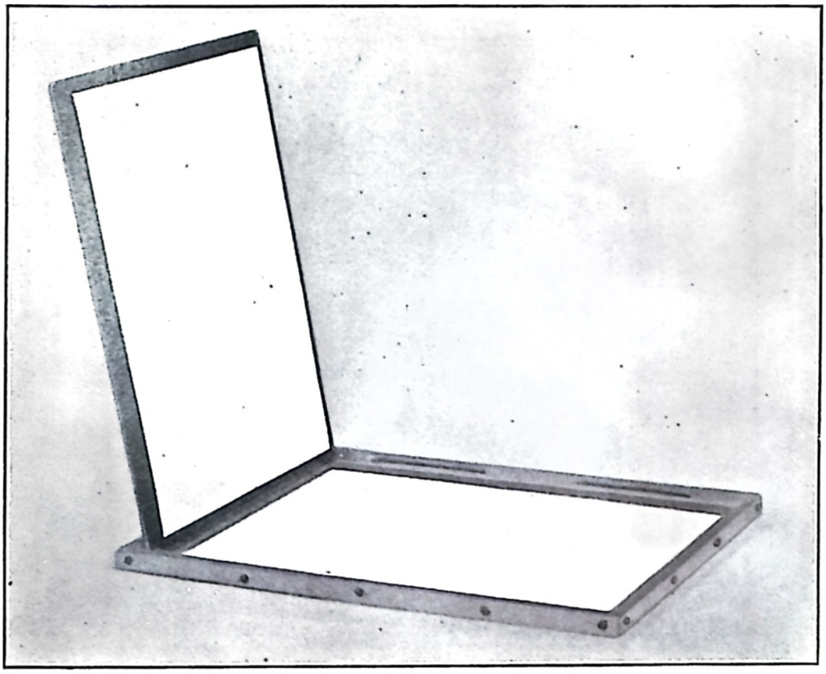


Figure 24

METHOD OF MOUNTING A SINGLE INTENSIFYING SCREEN

The first operation in mounting an Intensifying Screen in a cassette is to clean the bottom of the cassette carefully and brush off the felt coating on the lid with a stiff brush so as to remove all foreign particles or pieces of aluminum

that may be there. Each screen is shipped in an individual case and wrapped in clean white tissue paper. Remove this paper and wrap into it a piece of clean cardboard the size of the screen to be mounted and about the thickness of an X-Ray plate. Place this in the bottom of the cassette and it will prevent the sensitive surface of the screen from being in contact with any foreign substance which might attach itself. Then place the screen, **sensitive side down,** in the cassette. Take a tube of liquid glue and put a small drop, about the diameter of a lead pencil, in the places as shown in the cut. The screen will then be in the same condition as shown below.

With the finger, rub each drop a trifle and then carefully close the lid, being sure that the screen is centralized in the bottom. Fasten down the springs of the cassette and allow the glue to dry for about thirty minutes, and the screen will be ready for use.

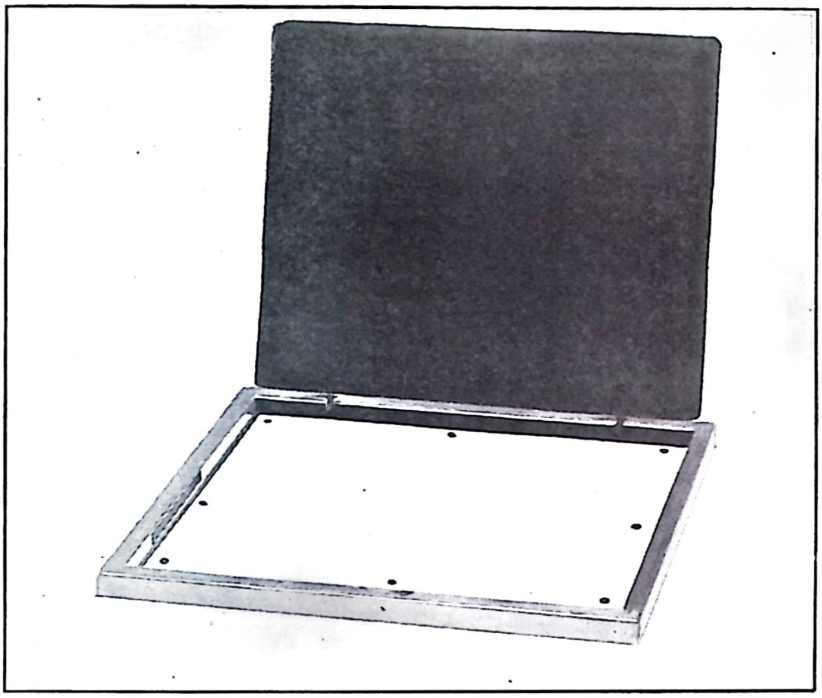


Figure 25

METHOD OF MOUNTING A SPECIAL INTENSIFYING SCREEN

In mounting a Special Intensifying Screen in the bottom of a cassette, better contact will be had if a thin piece of felt be mounted in the bottom first, and the screen mounted to this. It is advisable to cut the felt one-half inch smaller than the size of the screen for the reason that it will be entirely covered by the screen and do away with the possibility of the shedding of hairs.

The screen can best be mounted to the felt by means of Paper Transparent Mending Tape about five-eighths of an inch wide. Cut off four pieces about one inch long and fold them in the middle making a hinge. Moisten one-half of this hinge and fasten one in each corner of the felt. Then moisten part of the other half, place the screen in the cassette, sensitive side up, and close the lid. The advantage of using the paper hinges is that if for any reason it is necessary to remove the screen it can easily be detached.

CARE OF INTENSIFYING SCREENS

Intensifying Screens are made with the greatest of care and every precaution is taken to make each screen perfect and reach the Roentgenologist in this condition.

We are frequently asked how long a screen should last, and can best answer this question by saying that the limit of the life of an Intensifying Screen is governed by the care given it. Below we are giving a few essential precautions that will assist in making your screens last.

Each screen, or pair of screens, should be mounted in its own cassette for protection against bending or damage to the sensitive surface through handling.

Do not use a smaller size photographic plate than the size of the screen being used, owing to the danger of damaging the smooth surface with the edge of the plate. Neither do we recommend this practice when using films, particularly when using double screens owing to the danger of scratching the lower screen when localizing the film and when removing it after an exposure; furthermore, the mat-

ter of localizing when taking the picture is always a source of trouble.

When loading the cassette, carefully brush the screens and negative with a fine camel hair brush or a clean piece of double-faced cotton flannel in order to avoid dust spots.

Intensifying Screens may be cleaned with pure soap and water, sponging off with a tuft of absorbent cotton, and care should be taken to see that they are thoroughly dry before closing the cassette.

Developer spots may be removed to a large extent by the application of Hydrogen Peroxide to the spot on a tuft of cotton. Allow the application to rest on the spot for two or three minutes and then remove. If the spot is not entirely gone, apply fresh solution. This method is most effective if used as soon as the spot is noticed. Be sure that the screen is entirely dry before closing the cassette.

The table on which you load your cassette should not be near the developing tank, if it can be avoided, so to prevent the possibility of splashing the screens with developer or hypo.

One should not permit the emulsion to touch any aluminum part. When not in use, the cassette should be closed and a clean cardboard, preferably covered with white tissue paper, should be kept in the cassette.

If you are using double screens better contact will be had if a thin piece of felt be mounted under the Special Intensifying Screen in the bottom of the cassette.

EXPOSURES WITH INTENSIFYING SCREENS

Before attempting to memorize the data of an exposure table, it is well for every prospective operator to understand the fundamentals of radiograph production.

X-Ray pictures are made possible by the action of unknown light rays upon sensitized materials, as almost every individual understands. However, few realize the principles through which the complete production is accomplished.

Upon every X-Ray picture, if properly produced, there is a marked contrast between certain structures of the body, particularly between the soft tissues and the bony structures.

In the first place, this contrast is due to a difference in the density of the structures which show as contrasted.

For instance, every radiograph shows the osseous structure light in color, while the soft tissue is represented as the darkened area or black upon the negative.

This is all because the X-Ray waves penetrate these structures to different degrees.

X-Rays start upon the sensitized film or plate a certain definite action which is completed by the developing solution. The processes of exposing and developing go hand in hand, for either one is insufficient without the other.

Silver salts, particularly the bromides, make up a large portion of the sensitizing materials of a film or plate, and light will produce a chemical action upon the sensitive emulsion. The extent of this action depends partly upon the intensity of the light and partly upon the time of ex-

posure. Those rays of light capable of producing action upon sensitized materials are known as actinic rays, and X-Rays may be classified as such.

The contrast upon a film then is dependent upon a difference in light action upon its emulsion surfaces.

X-Rays focused from above the body pass through it and internally meet the resistance of the different body structures. The firmer and more dense the structure, the fewer the number of X-Rays that will penetrate it because of the greater resistance it offers.

Thus, lung tissue is more easily penetrated than is muscle; and likewise it takes greater penetration of rays to pass through osseous structures than is necessary for the complete penetration of muscular tissues.

In reality, the X-Rays penetrate the softer tissues quite readily, while the firm, dense structures resist penetration, and a shadow of these firm structures is cast upon the film underneath the patient or on the opposite side of the patient from the generation point of X-Rays. Certainly, the firm structures cannot be penetrated by the rays to as great an extent as are the softer tissues if contrast is to be expected. Because of this difference in the density of tissues, X-Rays have an uneven action upon the sensitized materials of the emulsion.

That portion of the emulsion upon which the rays have acted to the greatest degree turns darkest in the developing solution, while in proportion to the lessened action of the rays, the emulsion remains a lighter color after development.

The silver salts of the emulsion upon which the rays have their action are changed to a silver oxid compound by the developing solution. The density of this silver oxid under normal conditions is dependent upon the degree to which the rays have been allowed to affect the emulsion in making the exposure.

Realizing that the action of the X-Rays is uneven over the surface of the film because of a difference in the resisting qualities of bodily structures, and further that the density of silver oxid is dependent proportionately upon the degree of action of the X-Rays, the "why" of contrast upon an X-Ray film or negative need not be further explained.

The bony structures are seen as light in color upon the film because the emulsion underneath them during an exposure is acted upon to a lesser extent than is the emulsion covered by the soft tissues of the body adjacently located.

In fluoroscopy, the screen on the opposite side of the patient from the X-Ray tube is a substance which becomes fluorescent under the activity of X-Rays. The intensity of the fluorescence depends upon the intensity of the X-Rays acting upon the screen.

Again, the difference in penetrability of tissues makes a contrast possible, and X-Rays do not produce as great fluorescence upon the screen where their path is obstructed by bone as these same rays do upon that portion of the screen covered by the softer structures. The more resisting structures therefore are seen as the darker shadows in fluoroscopic examination.

Intensifying screens as used in making X-Ray film or plate exposures are constructed of a material which becomes fluorescent under the action of X-Rays just as does the fluoroscopic screen.

This material forming the fluorescent surface is Calcium Tungstate. If plates are used with intensifying screens, only a single screen is used, as there is emulsion on but one side of the plate. Should duplitized film be used, a double intensifying screen technic may be used in order that a fluorescent surface may be in contact with each surface of the sensitized emulsion of the film.

The screens, made of cardboard with the Calcium Tungstate spread over one surface of the cardboard only, are enclosed in an aluminum cassette, so constructed that it is a safe protection against light rays possessing less penetrative qualities than the X-Rays. The intensifying surfaces of these screens face each other, and protected against the light in the dark room, the film for exposure is placed between these two Calcium Tungstate surfaces. Each surface of the film is then in contact with a Clacium Tungstate or intensifying surface of the screen. The cover of the cassette is possessed of a spring, and by closing the cassette, pressure is exerted over both film surfaces, and evenly distributed.

The aluminum cassette offers but little resistance to the rays, and this resistance is equal over the entire area of the film.

Any difference in the action of rays upon the intensifying surfaces within the cassette is directly due to a difference in the degree to which X-Rays penetrate the structures

inside the body of an individual interposed between the cassette and source of X-Rays.

The principle of fluoroscopic exposure applies here. Under the action of the X-Rays, the Calcium Tungstate inside the cassette becomes fluorescent. There is a contrast in this fluorescence because of the difference in density of the structures of the body. The emulsion surfaces of the X-Ray film are sensitized to light and are acted upon by the fluorescence of the intensifying screens in direct proportion to the degree to which these screens become fluorescent, due to the X-Rays.

The developing solution completes the process of changing to a silver oxid that portion of the sensitized substances acted upon by the light, while the salts not changed to an oxid are dissolved from the film in the hypo fixing solution.

To prove that a very intense light if acting upon a film will make possible a very dense silver oxid, expose a film to daylight and note its color after it has been developed.

It is true that every structure of the body may be penetrated by X-Rays, providing the penetration of the X-Rays used is great enough and that the exposure is long enough.

This leads directly to the question of limiting exposures in such a manner that a maximum of contrast is obtained.

At a definite time during an exposure, the X-Rays have penetrated the structure immediately surrounding that one of which an outline is desired and yet have not to a great degree penetrated that one structure in question. The exposure should end here, for at this time a maximum of contrast is produced under those exposure circumstances.

Were the exposure shorter, the contrast would be less because the X-Rays have not had ample time to penetrate adjacent tissues. To prolong the exposure beyond this point would mean a greater penetration of the structure in question, consequently a heavier ray action upon the emulsion surface of the film beneath with a resultant proportionate lessening of contrast.

A very heavily exposed film is densely black after development, showing far too little outline and contrast to be easily readable, due to the fact that a prolonged penetration has obliterated the detail possible only through correct limitations of exposure.

It will apply that the more closely two adjacent structures are compared in resistance to penetration by X-Rays the more accurately must the exposure be made in order to obtain a contrast. On the other hand, it is comparatively easy to produce radiographs of structures which differ widely in density, and the more dense or resisting the structures, the easier they are to radiograph.

A very accurate exposure is necessary in order to produce a kidney picture because the kidneys offer very little more resistance to penetration by X-Rays than the tissues immediately adjacent to them. To prolong the exposure but an instant beyond that point, where the structures adjacent have been penetrated, would mean obliteration of the kidney shadow as the kidney would be penetrated as well.

However, bone offers such a great resistance in comparison to the softer structures surrounding it that a less accurate exposure is necessary, although the more accurate

the limitation of the exposure, the clearer will be the detail, and the sharper will be the contrast.

In the production of radiographs then, shadows are dealt with, and these shadows are produced as a result of different densities of proximal structures.

Intensifying screens are comparatively a late addition to the equipment used in the technique of radiographic exposures, and their usage is dependent upon their fluroescent property under the action of X-Rays.

That the screen becomes fluorescent means an increase in the effect upon sensitized materials by the rays which cause this fluoresence. Not only do the X-Rays themselves act upon the emulsion of the film, but by producing fluorescence of the tungstate surfaces the fluorescence has a definite action and effect as well.

Considering there is a double action on emulsion brought about by the use of screens instead of the separate action of X-Rays when used without screens, it follows that if intensifying screens are used it is possible to produce the radiograph with either a shorter exposure or with a less penetrative ray.

Without screens, a five-inch back-up spark is necessary to penetrate the body for spine pictures and affect the emulsion of the film to a desired extent. Using screens, a shorter back-up spark may be utilized because the production of screen pictures depends largely upon the fluorescence of the screen. This fluorescence is possible with a low as well as a highly penetrative ray so long as the ray is penetrative enough to pass through the body.

It must be borne in mind that the penetrative quality of X-Rays produced in an X-Ray tube is dependent entirely upon the back-up spark used in its operation. Further, the more penetrative the quality of the X-Rays used, the quicker will these rays penetrate the bodily structures, soft tissues and osseous formation as well. With high back-up spark, meaning high penetration, the exposure must be more accurately limited than with a less penetrative ray. This because the exposure must be checked at a time when the X-Rays utilized have completed penetration of the surrounding tissues, yet have not penetrated to any great degree the structure of which the radiograph is desired.

If highly penertative rays are used, it is found the greater is the extent to which these rays penetrate the firmer structures in comparison to those surrounding, with a consequent lessening of contrast.

So long as the rays produced are capable of penetrating the body in intensifying screen work, it is the aim of every operator to use a minimum of penetration to accomplish this result. The low penetration causes fluorescence of the screens where the rays pass through the body, while the same low penetration cannot act through the resistant structures proportionately as fast as do the higher back-up spark rays used without screens.

Screens actually make possible a shorter exposure with high penetration or a more definite contrast with low penetration and greater length of time.

At the Palmer School a 3½-inch B. U. spark is the foundation on which the intensifying screen technic has been developed.

This penetration has been used as the foundation because it produces on a medium sized individual a reasonable degree of contrast without undue or excessive exposure.

Previous to the usage of intensifying screens in spine work, a 5-inch back-up was the ordinary penetration used, and the foundation on which the technique was based.

The lower penetration used in the present screen technic offers possibilities for a sharper and more definite contrast although the time of exposure runs a trifle heavier than in exposures where the screens are not utilized.

While the aim is always to use the minimum of penetration for best results, it must be remembered that even with high penetration, spinal exposures are heavier than any other bodily exposures made in radiographic circles. The fact that spinal exposures are so heavy makes necessary certain precautions in technique used for the protection of patients against burn from the rays.

The lower the penetration used, the greater proportionately is the accumulation of dissipated X-Rays within the body lacking the penetrative quality necessary to work their way through the structures. Eventually, the accumulation of these rays losing their penetrative qualities within the body promotes possibility of erythema or X-Ray dermatitis to the patient and the exposure technique must be so limited as to guard against this danger.

Further than changing penetration to meet circumstances, it is advisable always to use an aluminum filter interposed between the X-Ray tube and the patient. This aluminum plate, approximately one-sixteenth of an inch in

thickness, filters out some of the rays which lack the penetrative quality necessary to pass entirely through the body and is a safeguarding appliance to be used by every operator in the best interests of patients coming under his care.

With a 3½-inch B. U. spark, an individual weighing approximately 150 pounds has been used as the subject for development of intensifying screen technic at The P. S. C. In accordance with experimentation and actual practice at the school the exposure table given later has been drawn up for the general information of every spinographer.

According to the make of intensifying screen used, there will undoubtedly be a slight variation at least from the exposure list as printed. It is merely meant that the use of this table will make possible the development of a spinal technique adapted to an operator's own equipment, subject to change as personal judgment decrees.

Further than a difference in the speed of screens of different manufacture, it is found that screens manufactured by the same concern will sometimes vary in their intensifying qualities.

A simple, yet effective manner of overcoming this variation is to number the screens, using each screen for a separate region of the spine or testing each screen separately in order to determine the advisable exposure for every region of the spine.

To date of writing but little use has been made of the intensifying screens for atlas and axis exposures. Due to the manner of exposing, i. e., through the mouth, but little

tissue is penetrated and hence the production of very good spinographs of this region without the utilization of screens.

The P. S. C. laboratories still adhere to the use of a 5-inch B. U. spark in the exposures of Atlas and Axis. An exposure table for all regions of the spine, without intensifying screens will be found on page 178.

The pictures hardest to produce accurately and consistently are those of children. Should the child be so small that it cannot be quieted to the extent necessary for complete elimination of motion, or should it be crying, it is almost impossible to produce a clearly readable exposure. For the output of pictures where motion is to be expected, very high penetration is essential. The vertebrae of children are composed so largely of cartilaginous materials that the highly penetrative rays necessary for "flash" exposures eliminate the probabilities of good contrast.

The lower the back-up spark possible in these exposures, the finer will be the contrast because of the lessened penetration of soft osseous structures of infancy. To use a low back-up spark, however, the time of exposure must be increased and motion has to be eliminated.

Should it be possible to completely quiet the child, the best results are obtained by testing for a 2½-inch B. U. and the exposure with 20 M. A. is from 14 to 22 seconds long, dependent upon the thickness of the case. If of a reasonably large size, or that normal to a child between the ages of 7 and 14, a 3-inch B. U. with approximately the

same time at 20 M. A. and 24-inch tube distance will show a fine result.

In obtaining a radiograph of Atlas and Axis on children, a cork may be placed between the teeth to separate the jaws. Any substance easily penetrated by X-Rays will do equally as well.

Although it is seldom necessary to use higher than a 5-inch B. U. spark, occassionally an individual is radiographed upon whom a greater than 5-inch B. U. penetration is desired. This is not because a 5-inch B. U. is not penetration enough to eventually produce the desired effect, but because the time is too great with a danger consequently to the patient.

Using on these exceedingly heavy individuals a back-up spark penetration of more than 5 inches, such as 6 inches or 6½ inches, the exposure will be considerably lowered, and it is an advisable course to follow.

Realizing that the Coolidge radiator type of tube is used largely in spinographic exposures, it is well to mention again the limited B. U. capacity of every radiator type tube, which is 5 inches.

Should a penetration of more than that equal to a 5-inch B. U. spark be desired or essential, either a Coolidge Universal or a gas tube must be utilized.

THE BUCKY-POTTER DIAPHRAGM

Radiographers have always had to contend with the effects of secondary radiations. These radiations, generally known as secondary rays, are produced wherever X-Rays are utilized and they have a definite shadow effect.

These secondary rays, still possessing penetrative qualities, will bring about distorted or abnormal shadows, for having lost their primary direction, they no longer penetrate toward the plate at right angles. A slanted shadow of the structure in question is consequently obtained.

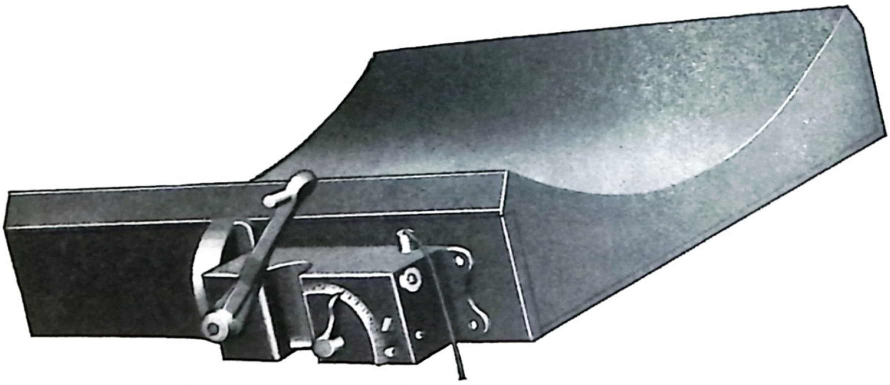


Figure 26—The Bucky-Potter Diaphragm

Due to these rays, a certain detail is lost on every X-Ray plate unless a method is employed to eliminate secondary effects.

As far back as 1913, Bucky, now living in Germany, conceived an idea for the elimination of scattered rays. The invention produced as the material form of his idea became known as a diaphragm, and having later been developed by Dr. Horace Potter, the name Bucky-Potter Diaphragm is adherent.

In brief its function is to absorb secondary radiations emitting from an individual's body before they act upon

the plate emulsion, but being so constructed that the primary or direct rays are effective.

In construction, this is accomplished by means of a moving "grid" or table. The "grid" is interposed between the patient and the X-Ray plate.

The diaphragms on the market at this time are approximately 25 inches square, the upper surface being concave crossways, and the length dimension is not curved.

The cover, on which the patient lies, or against which he stands, is made of either aluminum or wood, allowing for easy penetration with direct rays. Underneath this cover is the movable table or grid. It extends the entire length of the diaphragm and is arranged on tracks, with a "grid" side distance of approximaely 5½ inches across which the "grid" may move.

By means of a timing device, the grid may be so checked as to move the space of 5½ inches in 1 second, or at operator's desire taking over a minute to cover the distance. The motion is brought about by weights and compressions, action being started by the operator's utilization of a cord release.

The "grid" is made up of lead strips 1/50th of an inch in width, 9/16-inch deep and extending the diaphragm's full length. Between these lead strips are wood sections 1/6 of an inch wide, 9/16-inch deep and reaching from one end to end of the diaphragm. Actually 1/6-inch of wood separates each lead strip 1/50-inch in thickness.

Moving on a curved track, conforming to the concavity of the cover, the grid is just above the X-Ray plate which occupies a position in the bottom of the diaphragm.

Primary rays, focused from a target-cover distance of 25 inches will pass through the wood strips without being absorbed by the lead, and will therefore cast a direct and sharp shadow upon the X-Ray plate.

Secondary rays, being the result of primary rays meeting with resistance, cannot pass through the 9/16-inch thickness of wood without coming in contact with the wood boundary of lead. Resultant these rays are taken in by the lead strips and eliminated before reaching the X-Ray plate.

Unless a means of motion to the grid is provided, the lead strips produce detrimental shadows, grind motion is therefore maintained throughout the exposure, under which circumstances the entire plate is equally acted upon by rays reaching it.

The plate holder underneath the grid is so constructed as to accommodate any size plate up to 17x17 and opens to the side of the diaphragm allowing for easy replacement of the plate without necessity of changing the patient's position.

This is especially desirable where more than one picture of a single region is required as in a stereoscopic examination.

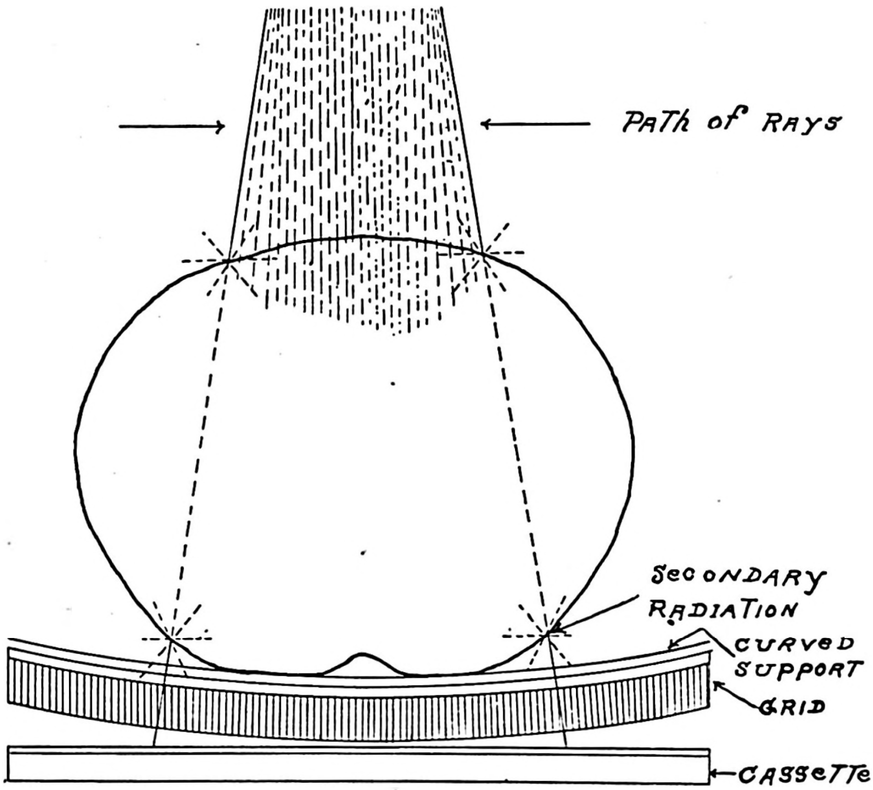


Figure 27—Schematic Drawing Representing the Path of the Primary Rays Passing Through the Body and the Function of the Diaphragm in Eliminating the Secondary Rays

Due to the 9/16-inch thickness of wood which is interposed between the patient and the X-Ray plate, exposures must be slightly increased to obliterate changed results due to this added resistance.

The preferable procedure is to increase the B. U. spark ½ inch above that previously used and to limit the exposures as the operator's judgment decrees necessary.

As secondary ray effects are unavoidably noticeable on plates of extremely heavy individuals owing to the greater secondary production in such bodies. The utilization of a Bucky-Potter Diaphragm is found to be highly beneficial.

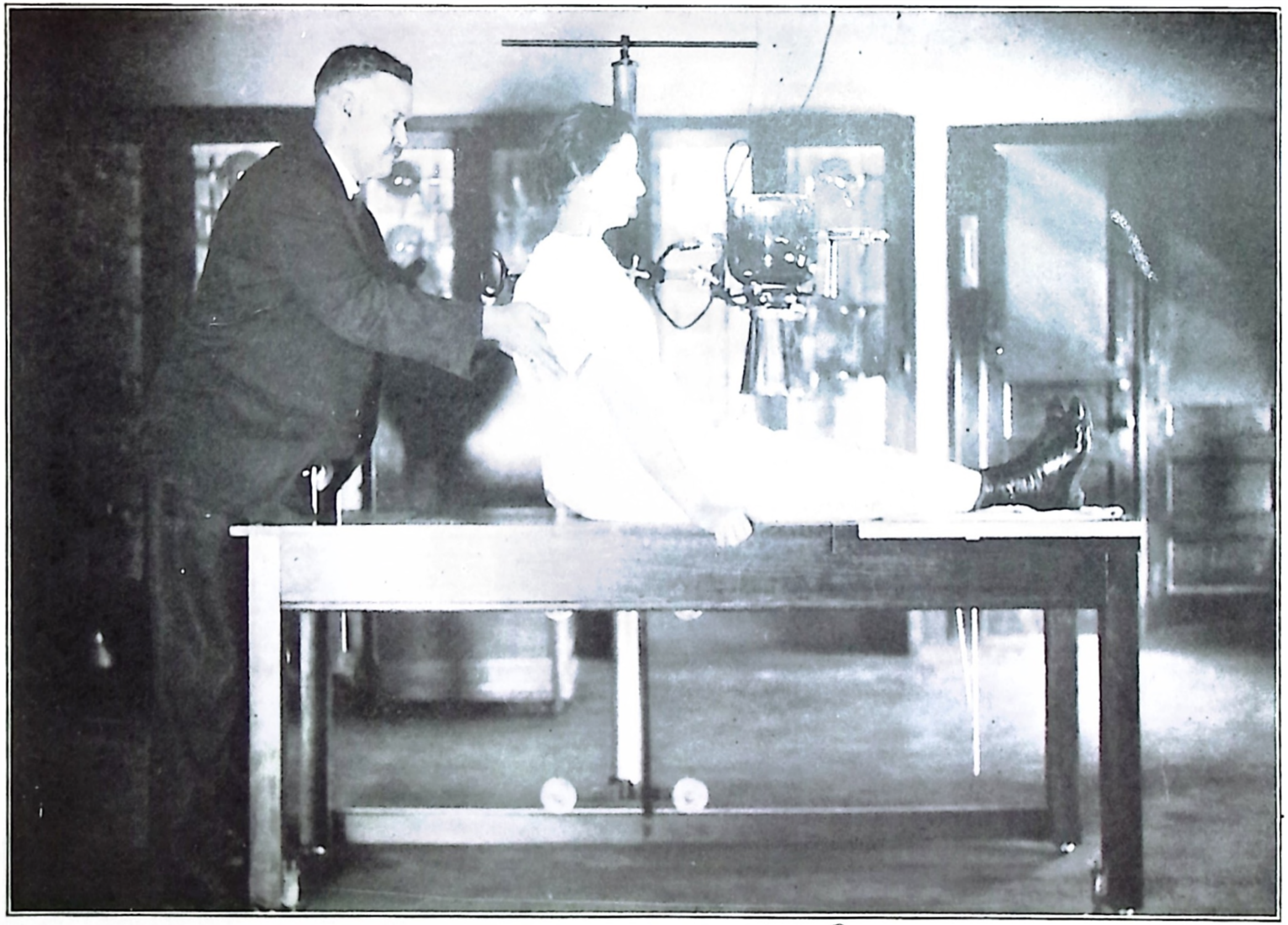


Figure 28—Showing First Position Assumed by Patient When Being Placed Upon the Table for a Spinograph

THE PLACING OF THE PATIENT AND PLATE FOR SPINOGRAPHS

The patient is prepared for a spinograph exposure the same as for palpation. Care should be taken that no pins, buttons, metals, or any other objects that offer resistance to the penetration for the X-Rays, are in the direct path of same, for the shadow may be reflected upon the spinous processes or other parts of the vertebrae and thereby cause difficulty in the correct reading of the plate.

In taking an exposure of the entire spine, four plates should be used. In using three plates, the mouth will have to be opened for the atlas and axis exposure and the rays will have to penetrate the mandible. As a result, there will be difficulty in reading the plate from the third to the sixth cervical vertebrae, as the shadow of the jaw will practically cover this region. A 5″x7″ plate should be used for atlas and axis alone. The mouth will then be closed and the exposure made from the third cervical downward. 8″x10″ plates are most commonly used for other parts of spine work.

It is advisable to palpate each case before making an exposure so as to be absolutely correct in placing the plate, but the rules given later for placing the plates apply to the majority of cases.

The following rules apply to spinography in general:

1. **Always** have the spine as near the center of the plate as possible.

2. **Always** place a marker in the upper right-hand corner so that when the plate is developed and ready for

reading, the marker can be seen from the glazed side in the upper right-hand corner.

3. **Always** place the plate for exposure with the emulsion side up (except when using an intensifying screen).

4. **Always** center tube directly over the plate or film.

5. **Always** have the patient assume a sitting posture first. Next place the plate and take the patient by the shoulders, having patient place the full weight on operator's hands and thereby help patient assume the recumbent position. If plate is not placed properly, which is determined by palpation, have the patient rise again and move the plate to the exact place. Have patient lie down and palpate again to see if plate is properly placed. If not, repeat the process until properly adjusted.

6. **Always** stand at the patient's head and look down over the body to see that he is lying straight.

7. **Always** see that the upper and lower edges of the plate are at right angles with the axis of the body.

After the plate and patient are properly placed; proceed according to the following instructions:

Whether the lumbar or the dorsal plate should be taken first in taking the entire spine all depends upon the size, weight, etc., of the patient. But the part requiring your greatest penetration should be exposed first, for the following reason:

The tube should be properly adjusted, i.e., of the proper penetration to make a certain exposure. Then take a lumbar plate after deciding that it shall be the first one taken. By running current thru the tube in making the exposure,

the tube is continually lowering, and by the time the exposure is made, the tube is not of the same vacuum, but lower in resistance. The next exposure will not require as much penetration, and as a result the tube will probably be of the proper vacuum. By the time the second exposure is made, the tube has again lowered, and then having a cervical exposure to make, the tube will be of the right vacuum. This applies to gas tube only. The Coolidge tube does not change in resistance after it has been properly tested.

For the Lumbar exposure, have the patient sit in center of table with legs extended straight away from the body. Now place the plate for the **lumbar exposure.** The plate should be placed so that the lower edge of the same will be approximately two inches below the superior crest of the ilium.

For the **dorsal exposure** place the plate 3 to 4 inches, which is determined by palpation, above the superior crest of the ilium. This will give a reading of the 12th dorsal and upward to about the 5th dorsal vertebra.

For the **cervical exposure** (anterior-posterior) from the third cervical downward, place the superior edge of the plate even with the lower edge of the lobe of the ear. This will cover approximately from the 3rd cervical to the 5th or 6th dorsal vertebrae. Have the patient raise the chin slightly so as to avoid interference with the passage of the X-Ray and thereby eliminate all difficulty in reading.

By having the head placed so that the X-Ray will pass through directly from one side to the other, this will be avoided.

For the atlas and axis (anterior-posterior) have the chin on a level with the forehead and have the patient open the mouth as wide as possible. It would be well to place something between the teeth so as to keep the mouth open continually until the exposure is made and avoiding a possible chance of the patient closing the mouth and spoiling the plate. Have the center of the plate even with the lobe of the ear, or palpate for the spinous process of the axis and center plate accordingly.

In taking an exposure to decide anteriority or posteriority of an atlas, the head should be placed so that the rays will pass through laterally and not an angle, for when the head is placed at an angle, the ramus of the jaw will obliterate the anterior portion of the atlas and thereby cause difficulty in reading.

For a lateral exposure of the cervical region, have patient sitting in his normal position, placing plate or film against the side to be taken.

The foramina in the cervical region emit anterior-laterally at an angle of about 45 degrees and not straight laterally. If a good outline and shape of the foramina is desired in this region, place the patient at such an angle that the foramina is on a plane with the plate, and center the tube directly over it. This will assist greatly in making a correct reading.

In taking a plate from the first dorsal vertebra down, have the superior edge of the plate visible immediately above the shoulders.

For the sacro-iliac articulation and coccyx, have the superior border of the plate slightly above the superior crest of the ilium.

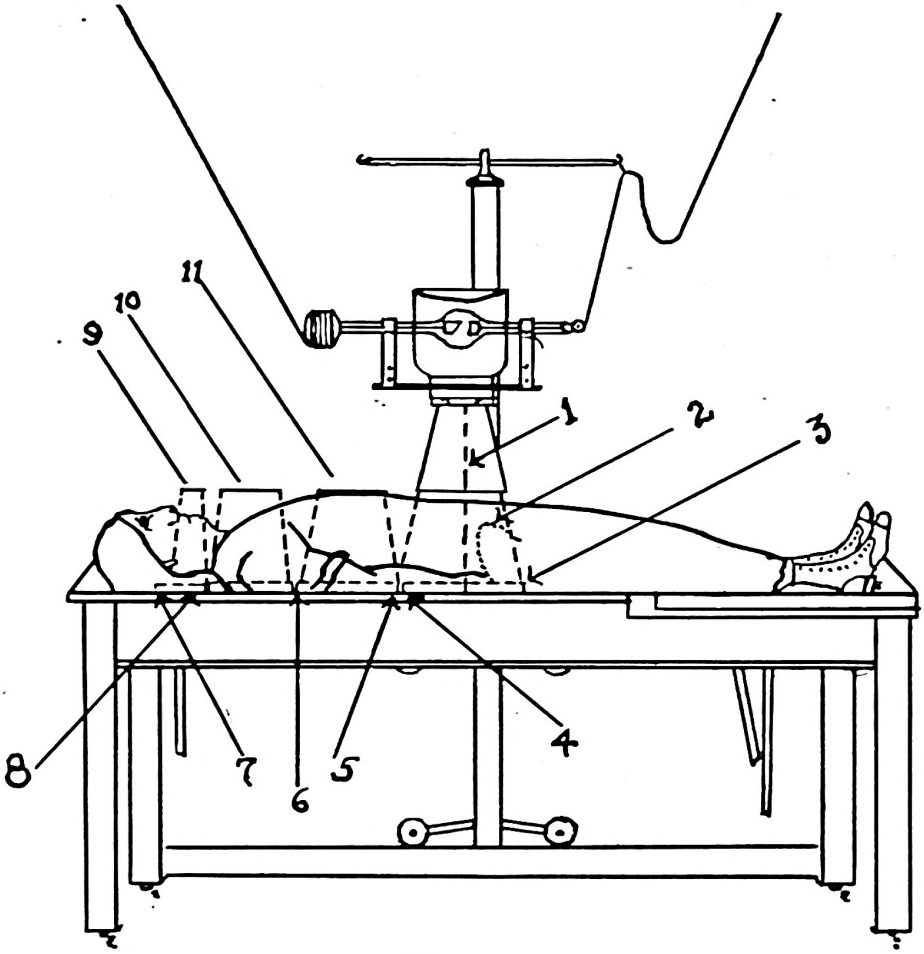


Figure 29

FIGURE 29

Illustrating the X-ray table with patient in proper position for spinographs.

No. 1—Indicates the center of the cylinder which is always centered over the region to be exposed.

No. 2—Indicates the superior crest of the ilium.

No. 3—Inferior margin of the cassette which should always be placed from 2 inches to 2½ inches below the superior crest of the ilium.

No. 4—The superior border of the cassette. Notice that path of ray covers the superior and inferior borders of the cassette. With cassette placed in this position and the X-Ray tube centered over it, all of the lumbar vertebræ will be shown upon the negative.

No. 5 and 6—Indicate the position of the cassette when the lower dorsal region is being taken with the inferior border of cassette No. 5 from 3 to 4 inches above the superior crest of the ilium No. 2. While No. 11 indicates the path of rays when this exposure is being made.

No. 6—Indicates the inferior border of the cassette when being placed for lower cervical and upper dorsal and No. 8 the superior border of cassette. Particular attention must be given to this region to see that the path of rays, as indicated by figure 10, just pass under the point of the chin and not directly through the chin.

No. 7—Indicates the superior border of the 5x7 cassette centered under the atlas and axis with path of rays, figure 9, passing directly through the mouth.

These instructions may vary with some individuals as all individuals are not the same physical proportion and it is necessary for the operator to use good judgment and place his plates accordingly.

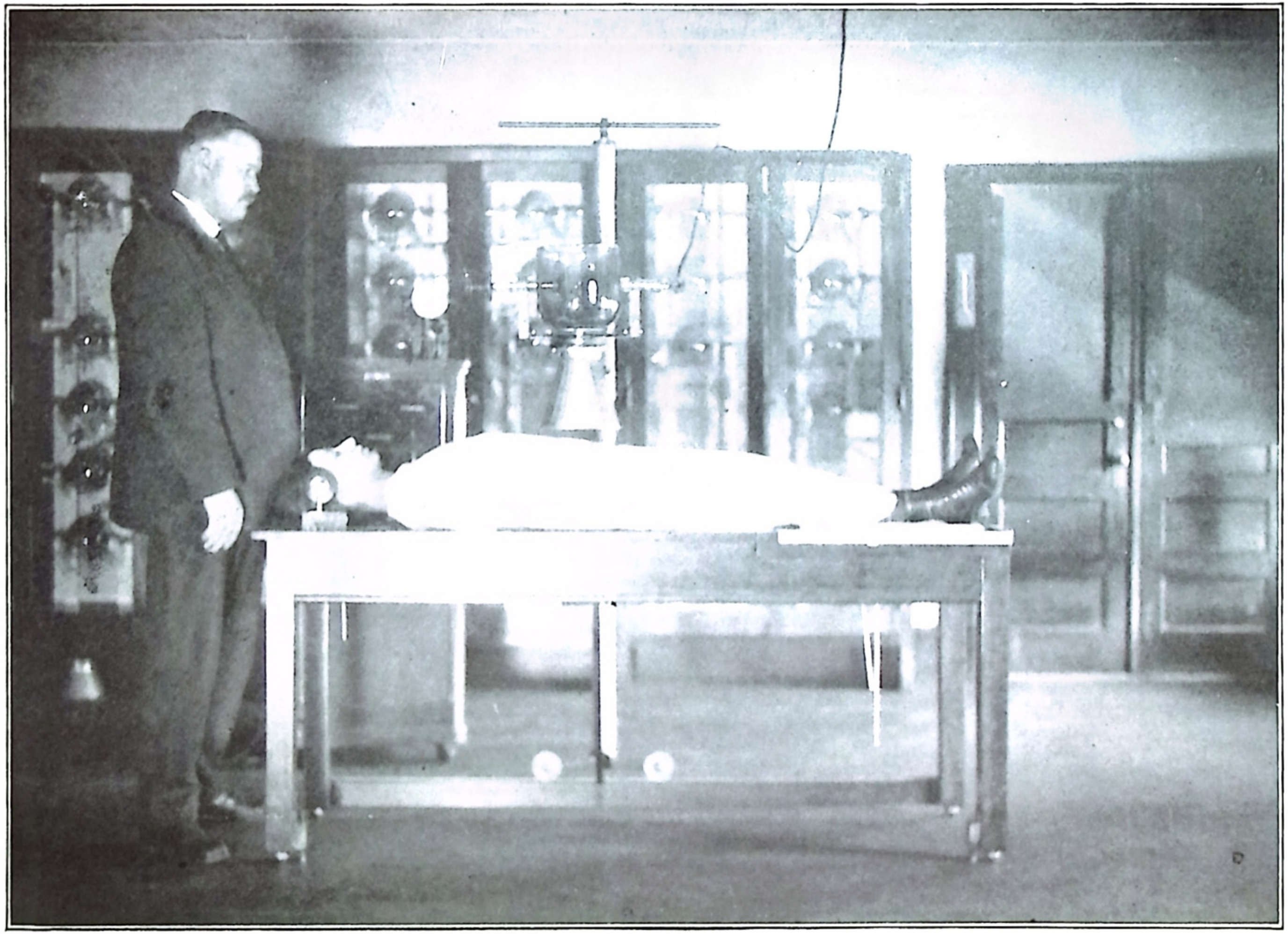


Figure 30—Showing Second Position of Patient with the Operator Standing at the Patient's Head to See That They Are in Alignment

SPINOGRAPHIC EXPOSURE TABLE

Without Screen, Based on a 150 Lb. Patent.

PARTS to Be Spinographed	Back-up	Tube Distance	Milli-Ampere Second
Lumbar Spine	.5 inch	24 inches	200 to 250
Lower Dorsal Spine	.5 inch	24 inches	250 to 300
Upper Dorsal	.5 inch	24 inches	180 to 200
Lower Cervical Spine	.5 inch	24 inches	180 to 200
Atlas and Axis	.5 inch	18 inches	100 to 120
Lateral View Cervical	.5 inch	24 inches	100 to 120
Lateral View Dorsal	.6 inch	Compression	500 to 600
Lateral View Lumbar	.6 inch	Compression	500 to 600

Exposure with Double Intensifying Screens.

125 lb. patient.

	M. A.	B. U.	Time
Lumbar	20	3½	20
L. Dorsal	20	3½	20
L. C. & U. D.	20	3½	15
At. & Ax	20	3½	15

150 lb. patient

Lumbar	20	4	20
L. Dorsal	20	3½	24
L. C. & U. D.	20	3½	17
At. & Ax.	20	3½	17

175 lb. patient.

Lumbar	20	4	23
L. Dorsal	20	4	20
L. C. & U. D.	20	3½	20
At. & Ax.	20	3½	20

200 lb. patient

Lumbar	20	4½	20
L. Dorsal	20	4	23
L. C. & U. D.	20	3½	24
At. & Ax.	20	3½	22

On patients of more than 200 lbs. increase time, it being but seldom necessary to use higher than 4½" back-up.

The operator must take into consideration that all patients weighing 150 pounds are not built along the same physical proportions. Some have larger chest development and are more muscular, while others have smaller chest development and a greater development of the abdomen. It is then that you must use your judgment in either increasing or decreasing the amount of milli-ampere seconds. In the following tables you will notice that I present one with the thickness of objects, back-up, tube distance and milli-ampere seconds, while in the other I have named the parts to be taken, giving the back-up, the time in seconds, the tube distance and milli-amperes. Multiply the milli-amperes by the time in seconds to obtain the amount of milli-ampere seconds to be given.

You will notice that I have mentioned very little about compression. Using compression means the bringing of the cylinder into contact with the abdominal region and pressing it down upon the patient just as tightly as they can endure it. This method is used by many operators in taking radiographs of the spine, while I only use it in heavy individuals.

I have found from experience that a 24 inch distance from target to plate gives the best detail, even though it may take a few seconds longer to make the exposure.

PART V

EXPOSURES OF OSSEOUS STRUCTURES OTHER THAN THE SPINE

In making exposures of osseous structures other than the spine, there are three rulings which must be followed in order that good results may be produced.

1. Have the center of the X-Ray plate under the structure to be exposed.

2. Center the X-Ray tube directly above the structure to be exposed, thus bringing the X-Ray tube over the center of the plate.

3. Have structure which is to be radiographed in close contact with the X-Ray plate.

The reason for having the object to be exposed as near the plate as possible is that more detail and contrast may be obtained. For example, hold a pencil under an ordinary light with a table beneath the pencil upon which its shadow will be cast. The nearer the pencil is held to the table, the clearer is the outline of its shadow.

In making exposures of the extremeties, it is best to make an exposure of both in order that the normal may be compared with the abnormal. This because the formation of structures varies slightly in different individuals, and what is normal to one may be a seeming abnormality in another.

With the foregoing instructions properly applied, any of the osseous structures may be properly roentgeno-

graphed. There are several exceptions to the preceding scale which will now be described.

Owing to the fact that different makes of plates have a variation in speed, further that one intensifying screen is sometimes found to be of a greater intensifying value than another, it is impossible to give in exact figures a technique which will not need corrections by each individual operator to meet individual circumstances.

However, a firm foundation can be given showing a comparison of exposures for different regions, and the actual exposure for separate regions will necessarily be subject to change in correspondence to altered requirements.

FINGERS

Two views are advisable, one to be anterior-posterior for the entire hand; the second, a lateral view for each separate digit.

HAND

Anterior-posterior and lateral views are essential in that an oblique fracture, dependent upon location, may not show upon a one way radiograph.

WRIST

Same positions as for hand. If desired to compare both wrists, place side by side upon the plate, marking for differentiation. For convenience where one wrist only is desired, cover half of the plate with a strip of sheet lead while anterior-posterior exposure is made. To obtain lateral view, cover the exposed portion of the plate with the lead

strip thus protecting it from further action by X-Rays. In this manner both views may be shown upon one plate.

ELBOW

Use an 8x10 plate, centering tube directly over the condyles of the humerus. Lateral and anterior-posterior views are usually desired.

SHOULDER ARTICULATION

Have patient assume a recumbent position and bring shoulder to be exposed in close contact with the plate by blocking up the corresponding opposite structure. If both shoulder articulations are desired on one plate, at least an 11″x14″ size is necessary and dispense with elevation of the shoulders.

CLAVICLE

Patient should lie upon the abdomen bringing clavicle in close proximity to the plate. Center tube over a point midway between the spine and the distal extremity of the clavicle.

If using an 11x14 plate to obtain both of the structures on one exposure, center the tube directly above the spinous processes of the vertebrae.

SCAPULA

A recumbent position is assumed and the arm on side of scapula to be exposed should be raised. This brings the scapula outward from the median line of the body. Center the tube slightly below the clavicle and just outside of the mamillary line.

STERNUM

Patient should lie face downward upon the table. By raising one shoulder about six inches from the table level, the rays may be directed perpendicularly to the plate without casting a shadow of the spine upon the sternum. This procedure is ordinarily followed.

Good results are often obtained by allowing patient to be upon the abdomen, rays then being focused at an oblique angle between the scapula and the spinal column. Either position may be satisfactorily used.

RIBS

Bring suspected area in close contact with X-Ray plate by having the patient assume any position necessary to that end. Focus the rays perpendicular to the plate and if desired, a marker, a resistant to penetration by X-Rays may be placed adjacent to suspected area for localization.

FEMORAL ARTICULATION WITH THE INNOMINATA

Stereoscopic examination is often times made for fracture of the surgical neck. An anterior-posterior view however is the ordinary exposure made. Patient is placed in a recumbent position and the rays are centered directly above the articular head. This point is ascertained by measuring inward about two inches from the center of a line drawn between the superior crest of the innominate bone and the greater trochanter of the femur. These land marks are located by palpation.

KNEES

Two views are taken for satisfactory knowledge in every respect. Patient lies in a recumbent position and with rays centered above the articulation point, the anterior-posterior exposure is made.

The lateral view is best obtained by having patient resting upon the side of the body, one leg thrown back from path of rays, the other in close contract with the plate.

The patella will show clearly only on a lateral view and its relative position is so determined.

ANKLE

Lateral and anterior-posterior views are ordinarily taken. For the anterior-posterior view, the patient may either lie upon the back or assume a sitting position upon the table. The X-Rays are focused centrally from above the ankle articulation and the foot remains in a natural position with the toes pointing upward.

The lateral view is taken the same as a lateral view of the knee with patient resting upon the side of the body or with thigh rotated so that the leg assumes a proper position for a lateral exposure.

.OS CALCIS

May be exposed in three ways and the first of these three, or the lateral view is made with the patient's leg in the same position as assumed for a lateral ankle exposure. The anterior-posterior view is taken with the heel bone against the plate and the rays directed through the tarsal bones while toes are elevated.

A superior-inferior exposure is taken with the toes flexed upward toward the anterior surface of the tibia and the tube at posterior of leg, foot flat upon the plate, tube tilted slightly at an angle if necessary.

FOOT AND TOES

Anterior-posterior view ordinarily desired. Foot rests firmly upon the plate, patient assuming a sitting posture upon an elevation placed upon the X-Ray exposure table.

HEAD

Exposures of the cranium are made by following the general rule of having the structure desired in close proximity to the plate with the X-Rays focused perpendicularly to the plate. It is sometimes necessary to tilt the tube somewhat at an angle, but the degree to which this is done should be limited, as the action brings about a slanted shadow conducive to distortion, thus presenting difficulty in reading.

X-RAY DENTAL WORK

The demand for this phase of radiography is increasing each day. All doubtful cases should be referred to the X-Ray operator by the dentist in charge, and the field is rapidly expanding.

The majority of the films used for this work are 1½x1¼ inches in size. There are several kinds of films used for dental work and commonly are known as

1. Slow film
2. Fast film
3. Metal back film.

Naturally the slow film requires a longer exposure than a fast film. In using the fast films, the exposure runs from 40 to 60 milli-ampere seconds at a tube distance of 18 inches.

The back-up spark varies dependent upon the thickness and consistency of the jaw. A back-up of 5″ will take the molars, using from 80 to 90 milli-ampere seconds with the slow film from 60 to 80 milli-ampere seconds for all other teeth with the same speed film. If a preference is shown to the use of slow films, it is because of an added detail possibility. This rule applies to an individual of medium size.

The film is placed next to the lingual side of the teeth and held firmly in place by the patient's thumb. A film holder for this purpose may be used.

The patient assumes either a lying or sitting posture, the former being preferable, as motion is better eliminated.

Two or three teeth can be roentenographed on one film. To take the entire set, ten films are required, five for the upper, and five for the lower teeth.

The film should be so placed that its border is on a line with the crowns of the teeth to insure obtaining the root shadow. The X-Ray tube should be so tilted that the rays are focused perpendicularly to the plane bisecting the angle between the X-Ray film and teeth in accordance with illustration.

Front uppers and lowers are exposed with the film placed long dimension vertical while on all other exposures the film is placed with the same dimension horizontal.

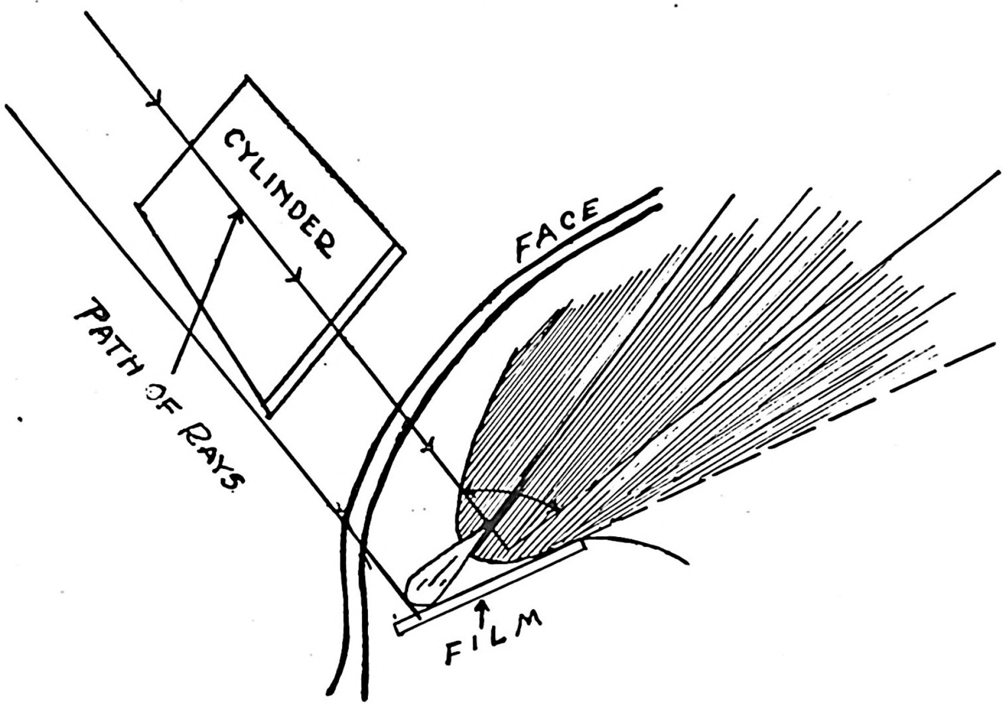


Figure 31—Illustrating the Proper Angle of Film and Path of Rays When Taking Radiographs of the Teeth

To insure good radiographs of the roots of the teeth, it is advisable that the operator place the film to make sure that the same is high enough or low enough to obtain the roots of the teeth wanted. The average individual if placing the film themselves will not get it high enough as the sharp corners of the film may hurt the patient a little but the average patient will let the operator hurt them more than they would hurt themselves. After film is placed in proper position, then instruct the patient how to hold it in place. For upper left, the film is held in position by placing the right thumb against it holding it firmly against the gums and roof of mouth, and the left thumb is used in the same manner when taking the right upper teeth. For the lower left, the film is held in position by using the right index finger against the film and the left index finger for the lower right, holding the film firmly in place while exposure is being made.

Some patients are more sensitive than others to the effects of placing the film in the mouth as nausea is easily produced if the film comes in contact with the palate. To avoid this, instruct the patient to breathe through the mouth. This condition is more easily produced in children and it may be necessary to have the film cut in two in order to get good radiographs of their teeth.

The technician that specializes in X-ray dental radiography uses the regular dental chair tipping it backward, flexing the head in correct position for radiographs to be taken, but it is not necessary to have a dental chair as you can purchase a head rest that will attach to any straight back chair and obtain the same results.

MILLI-AMPERE SECOND EXPOSURE TABLE

to be used without screens.

Thickness of Object	Back-up	Tube Distance	M. A. Seconds
2 inches	3 inches	18 inches	10
2½ inches	3 inches	18 inches	18
3 inches	3½ inches	18 inches	24
3½ inches	3 or 4 inches	18 inches	32
4 inches	4 inches	18 inches	40
4½ inches	4½ inches	18 inches	48
5 inches	4½ inches	18 inches	64
5½ inches	4½ inches	18 inches	80
6 inches	5 inches	18 inches	175
6½ inches	5 inches	18 inches	200
7 inches	5 inches	19 inches	225
7½ inches	5½ inches	19 inches	240
8 inches	5½ inches	20 inches	250
8½ inches	5½ inches	20 inches	256
9 inches	5½ or 6 inches	22 inches	296
9½ inches	6 inches	22 inches	340
10 inches	6 inches	22 inches	400
10½ inches	6 or 6½ inches	22½ inches	460

PARTS OF THE BODY EXPOSURE TABLE

Without Screen

Parts	Back-up	Time	Tube Distance	Milli-Amps.
Arm and elbow....	5 in.	1 Sec.	16 in.	25
Forearm and wrist.	5 in.	1 Sec.	16 in.	25
Fingers and toes...	4 in.	1 Flash	16 in.	20
Foot	4 in.	1 Flash	16 in.	20
Ankle	4 in.	1 Sec.	16 in.	25

Leg	5 in.	1 Sec.	16 in.	25
Knee	6 in.	1½ Sec.	18 in.	30
Femur	6 in.	1½ Sec.	18 in.	30
Pelvis	6½ in.	2½ Sec.	24 in.	40
Hip Joint	6 in.	2 Sec.	20 in.	40
Bladder	5 in.	2 Sec.—Compression		40
Ureters	5 in.	4½ Sec.—Compression		40
Kidneys	5 in.	4½ Sec.—Compression		40
Intestines	6½ in.	1 Sec.	25 in.	60
Stomach	6 in.	1 Sec.	25 in.	60
Chest	6 in.	1 Flash	27 in.	50
Shoulders	6 in.	2½ Sec.	20 in.	35
Head-lateral view	6½ in.	3 Sec.—Compression		40

OSSEOUS STRUCTURE EXPOSURE TABLE FOR USE WITH DOUBLE INTENSIFYING SCREENS AND DUPLITIZED FILM

		B. U.	Time	Tube Distance	M. A.
Fingers		3 in.	½ sec.	16 in.	20
Hand		3 in.	¾ sec.	16 in.	20
Wrist	A. P.	3 in.	1 sec.		
	Lateral	3 in.	1½ sec.	16 in.	20
Elbow	A. P.	3 in.	2½ sec.	16 in.	20
	Lateral	3 in.	3 sec.	16 in.	20
Shoulder		3 in.	5 sec.	24 in.	20
Clavicle		3 in.	6 sec.	24 in.	20
Scapula		3 in.	6 sec.	24 in.	20
Sternum		3½ in.	8 sec.	24 in.	20
Ribs		3½ in.	8 sec.	24 in.	20
Hip Articulation		3½ in.	14 sec.	24 in.	30

Knee........	A. P....3	in.	6 sec.	18 in.	20
	Lateral..3	in.	6 sec.	18 in.	20
Ankle.......	A. P....3	in.	3 sec.		
	Lateral..3	in.	2½ sec.	16 in.	20
Os Calcis....	A P....3½	in.	5 sec.	16 in.	20
	Lateral..3	in.	2½ sec.	16 in.	20
	S. I.....3	in.	3 sec.	16 in.	20
Foot and Toes.......	3	in.	½ to 1½ sec.	16 in.	20
Head.......	A. P....3½	in.	10 sec.	24 in.	25
	Lateral..3½	in.	10 sec.	24 in.	25
	I. S.....3½	in.	12 sec.	24 in.	25

SOFT TISSUE TECHNIC

It is not the intention of the author to cover the diagnostic features in giving this technic, as this part of Roentgenology requires a thorough knowledge of the normal structures involved, and if any diagnosis is attempted, the operator should familiarize himself with the anatomy of all parts involved. So that in covering this subject my aim will be to cover the technic that will assure good radiographs of parts desired. Radiographs of soft structures of the body, such as the oesophagus, stomach, small and large intestines, lung, heart, kidney, liver and region of the gall-bladder, all come under the heading of soft tissue technic and is not Chiropractic spinography, but for the convenience of all who are doing radiography or spinograph work, the technic which has proven to be the most satisfactory will be given, although it must be borne in mind that all technicians do not follow any given rule, or agree with some that have been given, so it is left for the operator to conscientiously try out the technic given here, endeavoring to improve upon it if possible.

Soft tissue exposures should always be taken with intensifying screens to produce the best results, although some very good soft tissue radiographs have been taken without them. The intensifying screen will make your shadows stand out much plainer, giving more contrast and detail with less exposure and is much easier on the tube.

The first soft tissue radiographs to be considered are those of the alimentary tract which is divided into four divisions. First, oesophagus; 2nd, stomach; 3rd, small intestine; and 4th, large intestine. These structures, being soft tissue, with little body, it is necessary that an opaque substitute be introduced into the part to be radiographed or the shadows of these parts will not be shown, due to the fact that the X-Rays would penetrate them. The substance that is being used universally for this purpose is Barium Sulphate, which is usually handled by all X-Ray supply houses. This Barium Sulphate is mixed with either buttermilk, malted milk or sweet milk and bread cubes, depending upon the taste of the patient. In some cases it is necessary to mix it with oat-meal porridge, or any other good cereal, the amount of barium sulphate to be given depends upon the size of the patient, never less than three ounces or more than five ounces, this being mixed with twelve ounces or sixteen ounces of fluid buttermilk, malted milk, sweet milk and bread crumbs. Add the barium sulphate to these fluids, continually stirring it until it is thoroughly mixed. The oat meal porridge is usually given when taking pictures of the oesophagus as the fluid passes through so quickly.

The operator should always emphasize the necessity of the patient abstaining from eating solid foods a day or two before any of these pictures are to be taken and the

solution should be introduced just before exposure to produce the best results.

The following technic will cover each division of the alimentary canal. First, the oesophagus. This picture should be taken with patient standing, the cassette holding the film placed laterally and firmly against the right side of the patient. The patient should rotate the left side of the body little anteriorly, so that path of rays will pass between the space found between the heart and spine as this space contains the oesophagus and its shadow will be clearly shown upon the film. In other words, the standing position of the patient is right antro-lateral and right oblique. These regions can be taken either from the posterior to the anterior or anterior to posterior, but the lateral view gives the best outline of the oesophagus.

OUTLINE OF OESOPHAGUS

Exposure with double intensifying screen. Tube distance 28 inches, spark gap 5 inches, milliamperes 40. Time, one-fourth of second. Without intensifying screen or single plate: Tube distance, 28 inches, spark gap, 6 inches, milliamperes, 60. Time, one second.

These exposures are based upon 150-pound individual. Should the individual be under or over, thicker or more muscular, the operator must do either of the following: increase or decrease milliamperes or increase or decrease time, but with a little experience in this kind of work the operator will soon develop his technic along these lines.

STOMACH

To obtain good radiographs of the stomach, it is necessary that the patient abstain from eating solid foods a day or two before the appointment, also instruct the patient not to use medicine or cathartics, as they may cause undue action of the regions to be radiographed. It is much better for the patient to use an enema the morning of the day that radiograph is to be taken, but this is not necessary when the bowel movement is normal.

Prior to the exposure, the patient is given a solution of barium sulphate and buttermilk or some other solution depending upon taste of the patient. The solution to be thoroughly mixed by stirring continuously up to time it is taken; after giving solution, fasten a coin on the umbilicus with adhesive tape. This being done for the purpose of giving a landmark which aids in reading the negative as the weight of the solution given will sometimes cause the stomach to drop below the umbilicus and may be mistaken for a prolapsus. Always allow a few minutes to lapse before making exposures, so that the contents of the solution will be thoroughly introduced into the stomach and over to the pyloric end of the stomach. If the exposure is taken too quickly after drinking solution, the true position of the stomach will not be shown. Some technicians prefer having the patient lie on the right side from ten to fifteen minutes, which helps greatly in getting the solution over to the pylorus and sometimes passing into the duodenum. After all these instructions are complied with, place the patient in position which can be taken, either standing or lying, although the standing position is best and has proven more satisfactory. Place the cassette or plate firmly against

the abdomen or let the patient hold the cassette firmly against the abdomen, centering it with the maker that you have placed on the umbilicus and center the tube accordingly, having the anode of the tube twenty-two to twenty-four inches away from film or plate. Owing to the fact that the stomach is in motion as soon as food is introduced, the exposure must be instantaneous or from one-fourth to one second's time, always depending upon the thickness to be penetrated. Always have the patient suspend respiration for this brief exposure, so as to stop all movement of the diaphragm.

The size of film or plate used for this kind of work is usually 11 by 14.

EXPOSURE WITH DOUBLE INTENSIFYING SCREEN

Tube distance	22 inches
Spark gap	5 inches
Milliampere	30
Time	½ second

WITHOUT INTENSIFYING SCREEN OR SINGLE PLATE

Tube distance	22 inches
Spark gap	6 inches
Milliampere	60
Time	½ second

These exposures are based on 150-pound individual. Should the individual be under or over this weight, thinner or more muscular thorough this region, the operator must do either of the following: increase or decrease milliamperes and increase or decrease time.

SMALL INTESTINES

When radiographs of the small intestines are desired, it is necessary to prepare the patient the same as for a stomach radiograph, in fact, a series of pictures should be taken of the entire alimentary tract, while the patient is properly prepared. About fifteen or twenty minutes after injection of the buttermilk it will be shown passing through the pylorus into the first division of the small intestine or duodenum. Two or three exposures should be made to accurately show the changes taking place in the pylorus and in the duodenum after the barium is given. Another plate should be taken about one hour after the barium milk has been given. In most cases the stomach will be about one-third empty while the small intestines are beginning to fill. Two hours after the first plate has been taken, the stomach will be almost empty, small intestines entirely filled, with cæcum beginning to fill.

The same technic given for stomach radiographs relative to tube distance, milliamperes, spark gap and time, changing time or milliamperes when size of individual varies.

As stated before, it must be borne in mind that all technicians do not follow the same technic with this particular kind of work, but if the operator will apply these methods given, good radiographs will be obtained.

LARGE INTESTINES

Radiographs of the large intestines are taken at different intervals to show: the particular part or parts of the intestines that may be involved in the symptoms given. Knowing that the large intestines are divided into eight

parts; cæcum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid flexure, rectum. The time that the barium meal reaches each one of these parts should be known. First, two hours after giving barium meal the cæcum will be found well filled. For four hours after, the ascending colon begins to fill. Ten hours later the ascending colon and transverse colon are well filled, showing the hepatic flexure and splenic flexure; twenty-four hours later the descending colon is shown as well as the rectum, and at this time the entire large intestine is well filled with all parts showing, and the appendix will be shown after the cæcum is well filled with barium meal. Forty-eight hours later some of the barium will be found in the descending colon and the rectum, providing, however, that the solution given has not stimulated bowel action which sometimes occurs.

The exposure technic for these radiographs are the same as given for stomach and small intestine relative to tube distance, milliamperes, spark gap and time, changing time or milliamperes when size of individual varies as stated before.

RADIOGRAPHY OF THE THORAX

This branch of radiography has proven to be a valuable one when diseases of its contents are suspected and it aids greatly in verifying the diagnosis that has been made. It is good policy to avoid making a diagnosis from the X-Ray alone. When all symptoms, both subjective and objective are taken into consideration, the negative should be used to verify the diagnosis only.

It is with this type of radiography that the use of the fluoroscope is most useful, as the observer is able to watch all movements of the organs suspected, which is much better than just taking the negative for study. It is advisable that it be used if one expects to do very much soft tissue radiography.

Radiographs of the thorax will show the lungs, trachia, bronchi, heart, aorta, esophagus, mediastinum and the bony walls that contain these organs. Owing to the fact that these organs are in motion, speed must be resorted to in order to obtain the best results. In fact, the shorter the exposure, the better the picture will be. It is here that the use of the intensifying screen is most valuable, as it helps to decrease the time of exposure and brings out brilliant negatives of the softer structures. It should always be used for this class of work.

The technic that produces the best results is one of high milliamperes and low spark gap. The higher the milliamperes the less time given, as the aim here is not to penetrate the softer structures. The osseous structures we care nothing about, and should a tube be used that is giving a high spark gap, there is danger of the rays penetrating the tissues wanted. A fine focus tube will produce brilliant radiographs of the thorax and its contents, if properly used. It must be remembered that this fine focus tube has a limit of twenty-five milliamperes and six-inch spark gap, but if used with a three-inch gap, it will easily stand a much higher amount of milliamperes and the exposure can be made in a shorter time. The time of exposure should never be over one second and shorter, if possible.

The size of plate or film that is best adapted for chest work is the fourteen by seventeen, although the eleven by fourteen will sometimes answer the purpose, especially in smaller individuals.

The standing position is best, although many technicians prefer the prone position. This is a matter of little importance as either position will give the desired results.

Have the patient take deep respiration two or three times before making exposure; then have him hold the breath with the lungs fully expanded and make the exposure instantaneous.

The following technic, if closely followed, will produce excellent results:

Exposure with double intensifying screen

Tube distance	28 inches
Spark gap	3 inches
Milliamperes	40
Time	1/4 second

Exposure with X-Ray Plate

Tube distance	28 inches
Spark gap	6 inches
Milliamperes	60
Time	1 second

This technic is based on a 150-pound individual. Should they weigh over or under (be thinner or more muscular) the milliamperes and time must be either increased or decreased respectively. As the beginner will soon learn, the exposure given for a 150-pound patient will not make a radiograph of a 200-pound patient, and it is advisable not

to try it. When using plates or films this size, it is necessary to remove the cone so that the rays will cover the entire area of the thorax. When taking pictures without the intensifying screen where a six-inch back-up and sixty milliamperes are used, a tube of broad focus is better adapted, as it is made to stand a greater amount of current.

RADIOGRAPHY OF THE URINARY TRACT

Good radiographs of the urinary tract can be obtained with very little trouble when the proper technic is applied, and there have been many technics presented to cover this particular kind of radiography. Some have proven failures, some successes, but the best technic that has been advanced to the X-Ray field is that of low penetration, with the use of the intensifying screens. It might be stated here that the use of intensifying screens has made it possible to use tubes of low penetration very successfully.

Radiographs of the kidney, ureters and bladder will show the shadows of any obstruction that may be present, such as kidney stones, renal calculi in the ureters and bladder. Do not expect to obtain a good radiograph of the ureters or bladder when these organs are normal, as they, being very thin structures, cannot be shown unless there is some pathological condition present. In the case of the kidneys, consisting of more tissue, and covering a greater area, good radiographs can be obtained.

The patient is prepared for these radiographs the same as for stomach or intestinal pictures, with the exception that there is no barium meal given. The patient should be placed on a diet a day or two before the exposure is to be made and the bowels thoroughly emptied. The patient

should also use an enema just previous to the exposure. All these factors must be closely followed, as some times shadows will appear that may be mistaken for stones or deposits of calculi when they are nothing more than an opaque substance which has not been removed from the intestines.

The patient is placed in the dorsal position with the knees flexed, the head raised for the kidney exposure. Place the plate or cassette under the region of the kidney, centering tube accordingly, then use as much compression as the patient can bear. Now instruct the patient to hold the breath while the exposure is made, so that all motion of the diaphragm is suspended. A punching bag bladder placed between the compression cylinder and patient's body, with a bicycle pump attached to it, makes a very good method for producing compression in this kind of work, or any other kind of work where compression is desired.

The following exposure technic is recommended to produce good radiographs of these regions:

Exposure with double intensifying screen

Tube distance................	Compression
Milliamperes	30
Spark gap....................	3½ inches
Time	8 sceonds

Exposure with X-Ray Plate

Tube distance................	Compression
Milliamperes	30
Spark gap....................	5 inches
Time	5 seconds

This exposure table is based on a 150-pound patient. For patients heavier, or lighter than this, a slight increase or decrease of the time will be necessary.

URETERS

When radiographs of the ureters are desired, the compressing cone should be placed a little lower over the abdomen along the line of the ureters, or centered over the suspected obstruction. The same technic is used as given for the kidney radiographs.

BLADDER

Here the patient is placed in the prone position, with the plate or cassette centered under the pelvis. In this position a clear view is obtained as there is no obstruction in the path of the rays. The same exposure technic is applied here as for the kidney radiographs.

The following pathological conditions can be determined by radiograph negatives of the urinary tract: Calculi, tumors of kidney and bladder, tuberculosis of kidney, hypertrophy of the bladder, and other abnormal conditions can be shown.

GALL STONES

Radiography of the liver, bladder and bile ducts is considered one of the most uncertain phases of X-Ray technic, relative to the showing of gall stones. The shadow of the liver can be clearly shown, but the gall bladder and bile ducts will not show unless some pathological condition exists and in the greater percentage of cases that have

every symptom of stones, the negative fails to show them. This fact is due to the chemical composition of the stones. The stones that do show are found to possess a great amount of lime salts, while the rays may penetrate stones of other chemical composition in the majority of cases.

A careful preparation of the patient is absolutely necessary, the same as for kidney technic, and in many cases it may be necessary to take a second or third exposure due to the fact that the gases in the intestines will show a dark blotch in the region of the gall bladder.

The prone position has proven to be the most satisfactory, although exposures can be made with the patient in the dorsal position. Using the prone technic, place the plate or cassette under the region of the gall bladder, centering the compression cone directly over this region, rotating the upper part of the body to the left. A small cone is more desirable for this kind of work as it is possible to centralize the rays over a smaller area. The exposure should be short, with patient suspending respiration during exposure. Be very careful not to over-develop this negative. In fact, it is better to under-develop, as some gallstones will be lost if full development is given.

The exposure technic varies with most technicians, but the following technic will help greatly in obtaining correct results with this phase of radiography:

Exposure with double intensifying screen

Tube distance................	Compression
Milliamperes	30
Spark gap....................	3 inches
Time	5 seconds

Exposure with X-Ray Plate

Tube distance................	Compression
Milliamperes	30
Spark gap....................	5 inches
Time	7 seconds

The above exposure is based on an average 150-pound patient. For individual heavier or lighter, a slight increase or decrease is necessary.

It must be borne in mind that there are many factors to be considered in producing satisfactory results, and a great deal of the technic given will not always seem to work out with some particular type of apparatus, or tube; these facts being considered, it devolves upon the technician to use his knowledge and judgment in finding the difficulty.

TUBE DISTANCE

In the earlier stages of roentgenology exposures of various parts of the body were more or less guesswork and are still today with some technicians, but for the consideration of the technician who wishes to be accurate with his exposure technic he can take into consideration the following methods that are now used: The five factors that are absolutely essential in producing good radiographs are applied as follows: The **tube distance** from the anode or target to the X-Ray plate or film, the **thickness** of the object to be penetrated. **Penetration** or the speed of the X-Rays being produced; the current or **milliamperes** passing through the tube; the **time** in number of seconds that object is to be exposed.

The spine has been, and still is, one of the hardest regions of the body to radiograph, so that all parts and shadows of the vertebra are clearly outlined.

Spinographic technic has been our specialty from the time we first used an X-Ray equipment; by making it our specialty we feel that we have improved and developed this part of X-Ray work into an art all its own.

The tube distance plays a very important part in taking good spinographs, as it is our aim to have the spine stand out sharp and clearly on the plate, that it may be more easily read from a Chiropractic standpoint.

For this reason we must consider some of the laws of physics that have to do with relation of intensity of light to the distance. It is self-evident that any light is dimmer the farther away it is. This is a very definite law and in the study of physics it is known as the law of Inverse Squares.

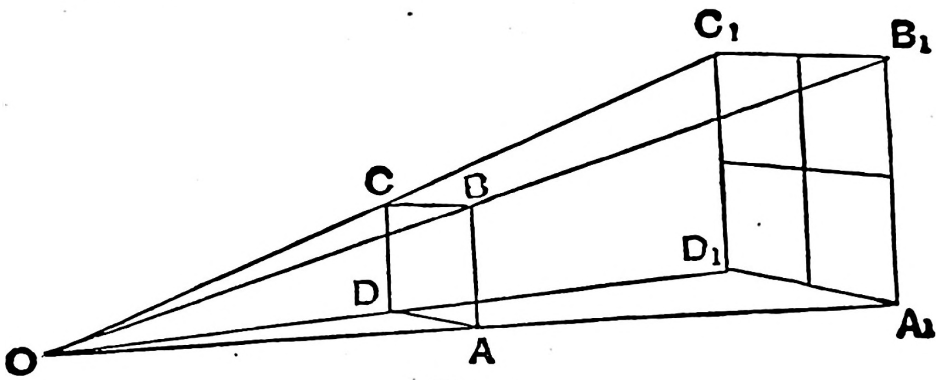


Fig. 32

In the above diagram suppose O is a candle or other source of light and A, B, C, D is an opening one foot away

from O. Letters A_1, B_1, C_1, D_1, represent a screen two feet from O. It is evident that the amount of light passing through A, B, C, D, covers four times the area when it reaches the screen two feet away.

The law is generally stated that the intensity of a source of light varies inversely with the square of the distance; in the above diagram it would take four times as long for a given amount of light to reach a square inch of area on the screen as it would a square inch on A, B, C and D.

This same law is applicable to the X-Ray. We must, however, consider the length of the first exposure, and the distance of the target from the plate. We must then consider the distance of the target from the plate in the second exposure and from this basis must compute the length of time required.

Assume that in the first instance the distance of the target from the plate is 12 inches and the exposure is for 3 seconds. In the second instance the distance of the target from the plate is 24 inches and the length of time must be computed.

The foregoing assumes that the tube conditions are the same.

Let X represent the time for the second exposure.

$$\frac{3}{X} = \frac{12}{24}$$

$$\frac{3}{X} = \frac{144}{576}$$

$$\frac{3}{X} = \frac{1}{4}$$

Multiplying the means by the extremes we have

$$1 \times X \qquad 3 \times 4$$

$1X = 12$ seconds as the length of time for the second exposure.

Example: Under certain tube conditions an exposure of 10 seconds is required with the distance at 24 inches. What would be the time of exposure if the distance were 18 inches?

Let Z represent the length of time for the second exposure.

$$\frac{10}{Z} = \frac{24^2}{18^2}$$

$$\frac{10}{Z} = \frac{576}{324}$$

$$\frac{10}{Z} = \frac{16}{9}$$

Multiplying the means by the extremes we have

$$16 \times X = 10 \times 9$$

$$16Z \quad = 90$$

$Z = 5\frac{5}{8}$ seconds as the length of time for the second exposure.

Under certain tube conditions an exposure of 10 seconds is required at a distance of 25 inches. What would be the time of the exposure if the distance were 15 inches?

Let Y represent the length of time for the second exposure.

$$\frac{10}{Y} = \frac{25}{15}$$

$$\frac{10}{Y} = \frac{625}{225}$$

$$\frac{10}{Y} = \frac{25}{9}$$

Multiplying the means by the extremes we have

$$25 \times Y = 10 \times 9$$

$$25Y \quad = 90$$

$Y = 3^3/_5$ seconds exposure for the second distance of 15 inches.

It is well in comparing times of exposures at different distances to take only such distances as have a simple relation to each other. In this way the problem can be solved very quickly as indicated above. In other cases the method is the same, but requires more calculation.

Example: Under certain tube conditions if an exposure of six seconds is required at a distance of 17 inches, what exposure would be required at a distance of 23 inches?

Let W represent the time of the second exposure.

$$\frac{6}{W} = \frac{17^2}{23}2$$

$$\frac{6}{W} = \frac{289}{529}$$

Multiplying the means by the extremes we have

$$289 \times W = 529 \times 6$$
$$289W = 3174$$

$W = 10\ {}^{284}/_{289}$ or very nearly 11 seconds as the time for the second exposure.

For illustration say the tube distance for a certain exposure was 18 inches and required 200 M.A.S. If the tube distance were increased to 36 inches or twice the distance from the plate, the exposure, instead of being 200 M.A.S. would be 2×200 M.A.S. or 800 M.A.S. If the distance is 27 inches instead of 18 inches the exposure will be 2 times 200 M.A.S., or 400 M.A.S., the plate being twice as far away from the tube focus as given in the preceding scale, the exposure will be 4 times as long. The exposure in which the tube distance varies several inches can be determined from the preceding instructions.

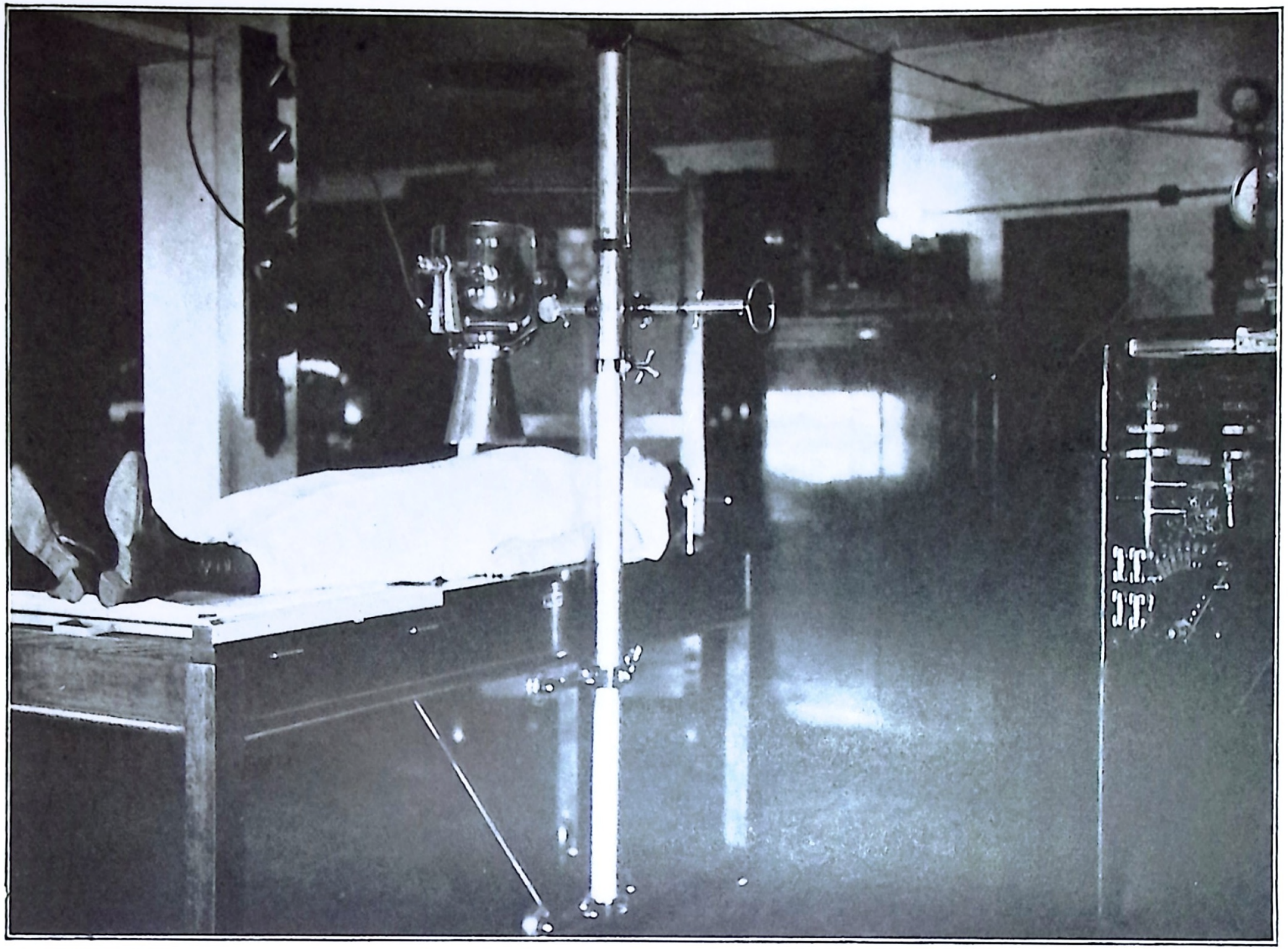


Figure 33—Another View of The P. S. C. Spinographic Laboratory Showing Proper Position of Patient Upon the Table and Operator Standing Behind the Lead Screen, Ready for the Exposure

PART VI

PHOTO CHEMISTRY

It was due to the sensibility of a photographic plate that X-Rays were positively identified. The chemical action of light upon many chemical compounds had been known for some time prior to the discovery of the X-Rays, but this form of light could not be seen with the naked eye and it was left to the ordinary photographic plate to prove that an invisible ray did exist when a high tension current was passed through a vacuum tube.

The most sensitive compounds to light are the halogen salts of silver. Passing through many years of experimentation we have at the present day reached a method of incorporating these salts in a gelatine base which is coated onto a flexible support or onto a glass surface. The flexible supports are known as films and the glass as photographic plates.

During the years of experiment it was discovered that different combinations of these salts with other compounds gave rise to an emulsion (the mixture of the halogen salts of silver with the gelatine) which was adaptable to various kinds of photographic work. For example, it was noted that a certain combination was especially adaptable for landscape photography as it gave a greater differentiation in the colors blue, green and red. Another combination was especially adaptable to portrait photography because of the depth of the shadows, etc. Another combination was of greatest use for taking pictures where a very high degree of speed was necessary, and so it goes until we have at the

present a photographic plate or film for every special branch of photography. Naturally it would follow that a special emulsion should be devised for the use with X-Rays and adaptable for this work exclusively.

In all of these different combinations the essential compound is bromid and chlorid of silver and added to these are other compounds which produce the special effects above enumerated. It is impractical for the photographer to coat his own plates as the mixture of salts and gelatine have to be flowed onto the desired surface in several layers and each allowed to dry at an even temperature before the next is applied. This operation also has to be conducted under a very mild light, one that will not produce any chemical action upon the emulsion. To appreciate the delicacy of this operation, do not fail to avail yourself of the first opportunity to go through a photographic manufacturing plant. To complete the chemical action which the light, either actinic or X-Rays produce on these silver salts, the film or plate has to be put through two complex chemical solutions known as developer and fixing bath.

In all of these different combinations or emulsions, it is necessary that a special developer be used that will correspond to the ingredients in the emulsion to bring out the very best results. For that reason it is not desirable to use a portrait developer for landscape plates or an ordinary kodak film developer for X-Ray plates or films. The manufacturer of each and every brand of plates has a special developer adaptable to his particular emulsion and for the very best results that should be used. He has worked out a formula for his emulsion which will give the best results with his particular brand, and it can be depended upon that

it will, for photographic goods are sold entirely upon a competitive basis, each manufacturer trying to outdo his competitors.

All the formulas herein given are for use with X-Ray plates or films and intended primarily for that use only.

PLATE LOADING

X-Ray plates and films must be loaded in the dark room with the ruby light no brighter than is used to develop by. If you have not a special table for loading plates, be sure that your table or shelf is absolutely clean, allowing no chemical, dirt or moisture to come in contact with either plates or envelopes. Do not load plates just after having mixed or weighed some chemicals, as the air will be laden with chemical dust which will affect the emulsion of the plates, causing fog.

To protect the plates from the actinic rays of light, it is first placed in a black envelope and then an orange one. Before starting to load your plates arrange your envelopes alternately, an orange and a black, having the flap ends all in the same direction; this will eliminate all confusion in trying to find the correct envelope in the dark.

Open the box of plates, which will be found to have two lids, after all lights are out excepting the ruby light. The first plate in the box is always placed emulsion down, after which they are arranged in pairs, held together by proper clasps at each end, with the glass surfaces together. Thus they alternate, first one glass side up, the next emulsion side up, etc., the last plate being necessarily emulsion side up.

However, never attempt to remember the order of arrangement of the plates in the box when loading. Hold the plate to the ruby light and be sure which is the emulsion side before placing it into the envelope.

In radiograph work it is absolutely essential that you load your plates so that you will know which side carries the emulsion after it is placed into the envelope. The reason for this being that the emulsion side of the plate must always be placed next to the part to be radiographed.

The emulsion side of the plate is readily determined by holding at an angle close to the ruby light. This surface being dull gives little or no reflection, while the glass side is shiny and reflects the light. Should you not be positive by this method as to the emulsion side, moisten the index finger slightly and place on one corner of the plate. You will find that it adheres readily to the emulsion side, but not to the glass surface.

Fold back the flap of the black envelope and hold in such a manner that the flap will not rub against the emulsion of the plate while slipping into the envelope. By allowing the flap to rub over the emulsion you will find upon developing that it has caused fine pencil-like lines, brush-like scratches, called "abrasion marks." It is claimed this is due to the creation of static electricity and gives the greatest trouble in the winter months.

Hold your plate in such a manner that the glass side of the plate rests on your finger tips, the edge of the plate coming in contact with the thumb between the first and second joints. Never press the ball of the thumb or any of the finger tips on the emulsion of the plate, as it is sure

to leave the finger prints and might ruin an otherwise good plate. Slide your plate into the envelope with the emulsion side facing the smooth surface of the envelope. Most envelopes have the seam down the center of the back; this must be next to the glass surface of the plate. Turn the flap down and insert this end first into the orange envelope. The emulsion side is still face up, so place in the orange envelope in the same manner that you did the black, emulsion side towards the smooth surface of the envelope.

By loading your plates in this manner the seam of both envelopes are on the back or glass side of the plate, and for these reasons: first, the seam on both envelopes would make four thicknesses of paper through the center of your plate for the rays to penetrate and should your tube be low it would show on your plate as a light streak the entire length.

Second, commercial glue, or mucilage, with which the seam is made, has been found many times to contain small fillings of metal; these would make pinhead spots on the finished plate.

By making it a rule to load your plates in this manner you eliminate the danger of taking radiographs through the glass of the plates. While radiographs may be taken in this manner the glass has a tendency to cut off a part of the rays, thus lessening exposure of the plates. Also in taking radiographs through the glass side of the plates your image will be reversed and unless some form of marker is used, your readings will all be the opposite of their correct positions.

Do not load more plates than you will use in three days, as the chemicals of the paper affect the emulsion and may cause fog.

After loading, place in your lead cabinet, or at a distance of 60 to 80 feet from the X-Ray machine.

LOADING INTENSIFYING SCREEN

Great care must be taken in loading the intensifying screen to have the fluorescent surface absolutely free from all dust particles and stains. First wipe the screen with a photographer's camel hair brush, using a light sweeping movement; then wipe the emulsion of the plate in the same way. Place the emulsion side of the plate next to the fluorescent surface of the screen and close the cassette.

In using this screen it has been observed that the quality of the plate is greatly improved when the emulsion of the plate and fluorescent surface of the screen are in contact. Therefore you will be obliged to take your radiograph through the glass of the plate, consequently in reading be sure the emulsion is facing you and not the glass side.

The fluorescent surface of the screen should never be touched with the hands. Should it become dirty and stained so that simple brushing with the camel hair brush will not remove it, clean in the following manner: moisten a tuft of cotton with grain alcohol and wipe gently, or for stains use a solution of best grade of hydrogen peroxide. Be sure that the surface is thoroughly dry before placing your plate in position.

The finished plate will present many minute pinholes, which defects are due to the small particles of calcium tungstate of which the screen is made. It is an easy matter to distinguish a screen plate by this characteristic. **Remove the plate as soon as the exposure is made, because the pro-**

longed fluorescence of the screen will cause the plate to fog. If it is not to be developed immediately, place in the regular envelope and store in the lead cabinet. Develop in the usual manner.

Never store your intensifying screen in the dark room, where there are any chemicals or acid fumes; keep in a dry cool place, preferably the lead cabinet.

DEVELOPING

The process of developing finishes the chemical action which was started as soon as the rays struck the plate. It is essentially a chemical process and consists in oxidizing the silver salts contained in the emulsion. Only that part of the emulsion struck by the rays will become oxidized in the developer, the remainder will not be changed, but remains a lemon-yellow until dissolved by the hypo fixing bath.

Use only chemicals of a standard quality; have clean trays and an absolutely safe ruby light. These are paramount factors in producing the best radiographs.

Mix your developer by using equal parts of solutions A and B of the formula given later, having the temperature between 65 and 70 degrees. About ten ounces for an 8 x 10 tray is the most convenient amount; less would not cover your plate sufficiently while more would make it slop as the tray is rocked.

Remove your plate from the envelope, using the same care you did in loading. Turn the flap of the black envelope back so that it will not rub the emulsion as it slides out. Hold the plate, emulsion side up and allow it to slip on

the finger tips, catching the edge between the first and second joints of the thumb. **Keep the fingers off the emulsion surface.**

Slip your plate into the tray of the developer quickly, emulsion face up, and shake the tray vigorously to be sure that it is evenly covered and to remove all air bells. Air bells, or bubbles, must be dislodged within the first thirty seconds the plate is in the developer or they will remain throughout the process and be visible on the finished plate as round transparent spots and pinholes. Rock the tray gently throughout the development to keep any sediment from settling into the emulsion and also to expedite the process.

The time for development will depend upon the exposure of the plate and the temperature of the developer. For the finest chemical results the temperature of the developer should be 65 degrees. Warmer developer softens the emulsion, making it very sticky, and develops the plate too rapidly, which is likely to cause them to be streaked and uneven. A lower temperature allows it to develop too slowly, permitting of chemical fog.

The density of the negative will increase as the time of the development is prolonged up to the point where the emulsion is oxidized entirely through to the glass of the plate. By occasionally lifting the plate out of the developer and looking at the back you will be able to see to what extent it is developing. **When it is entirely developed the plate will look the same on both sides.**

When you carry development beyond this point chemical fog will set in and will be noticeable by the yellow

emulsion, up in the corner where the maker is placed, turning a gray, smoky color. Further development will only deaden the contrast of the lines and make your plate harder to read.

A ten-ounce tray of developer should not be used for more than six to ten plates.

RINSING

Remove the plate from the developer and rinse for half a minute in clean cold water. Should you place your plate directly in the hypo, or fixing bath, without first rinsing, you are very likely to cause minute blisters over the entire surface, thus making an unsightly plate and one very difficult to read. This is because the developer is alkaline in reaction and causes a violent chemical reaction with the fixing bath, which is strongly acid.

FIXING

After your plate has been in the fixing bath for three minutes it will be safe to turn on your white light.

Your plate should be clear, that is, all the yellow of the emulsion removed within five minutes after placing in the fixing solution. Allow your plate to remain in the fixing bath for at least five minutes after it is cleared, for while it looks transparent the unoxidized silver will not all be dissolved out. Therefore, ten minutes is the minimum length of time they should be left in the hypo bath, fifteen to twenty minutes is absolutely safe, and longer will not hurt. By leaving them in your fixing bath several hours a

slight reduction takes place which reduces the density of the plate.

WASHING

Plates are more easily and quickly washed by using running water. Do not allow the force of the water from the tap to fall directly on the plate, as it invariably raises the emulsion. A regular plate washer can be attached to the tap, but a rubber tube is preferable. Allow the plates to wash fifteen minutes in running water, or, if running water is not available, wash in ten complete changes of water, consuming thirty minutes in all. Should the tap water be riley, put on a filtering cap, as any sediment in the water will settle in the emulsion of the plate.

DRYING

Great care should be taken in properly drying the negative, as often a good plate is spoiled by careless drying. They are best dried in a room of normal temperature which is free from dust. Do not attempt to dry quickly by placing in a warm place or in the sun, as the emulsion will melt and run off the plate. Place on a drying rack and not too close together, as they are likely to dry unevenly and slowly, which may leave drying marks.

Removing from one room to another of different temperature after a plate is partially dried will vary the density of the part which dried last. This causes large circular spots.

In cold weather do not leave where the moisture will freeze on the plate before it is dry, as this will give a mottled appearance.

Should you wish to dry the plates quickly, place them before an electric fan. The harder the gelatine (the emulsion) is fixed on the plate, the quicker it will dry. The emulsion can be hardened to a greater extent by placing the plate, after it is all fixed and washed, in a five per cent solution of formaldehyde for five minutes. Another method of quick drying is to moisten a tuft of cotton with grain alcohol and gently swab over the surface of the plate and then place before the fan. If you use the latter method, be sure all hypo is washed out of the plate.

DEVELOPING PROCEDURE

Tank Method

The use of tanks for developing kodak films, photographic plates, and photographic films, has been in use for some years, and today we find it universally used. The chemical process is essentially the same as the tray method, and differs only in the amount of work and time required. As the name will indicate, the developer is placed in a tank of suitable size so that when a film is placed on edge it will be entirely immersed. These tanks are specially constructed containers made in various sizes to accommodate the different sizes of films and of such material that they will not be acted upon by the chemicals. These can be purchased from any photographic dealer at a very nominal cost.

Some very successful photographers use a weak developing solution, thereby necessitating a longer time in the developer, which they claim gives them a much finer grade in the silver deposit of the negatives. As it is not necessary that the Roentgenologist have the same quality

of negative in this respect as the portrait photographer, we can use the developer at the same degree of concentration as we do for the tray method.

The formula following this article has given us very satisfactory results, and we can recommend it; we are indebted to the Eastman Kodak Company for its use. Before endeavoring to mix it up, measure the capacity of your tank and make about one-half gallon more than is necessary to fill the tank. This extra quantity keep in a closed container and use to refill the tank as it is gradually carried out by removing your films from it. Here I wish to recommend that a floating lid be used to keep as much of the air from the filled tank of developer as is possible. These lids are not supplied as a part of the complete tank, but are furnished to those that wish them at additional cost. As has been stated before, developer will oxidize on contact with the air and become useless regardless as to whether it is being used or not. Therefore, the advisibility of keeping all the air possible away from it. When the temperature has been reduced to 65 degrees it is ready to use, and let me impress upon you that the temperature of the developer when this method is used is just as important as when the tray method is used.

In order that the film may be held in proper position while in the tank, a special metal hanger has been devised which grips the four corners of the film and holds it flat. A special loading device is also provided which eliminates the danger of finger marks while loading the films onto these hangers. The films are removed from the holders and the enclosing black paper discarded under the same special X-Ray ruby light by which they were loaded and

fitted onto the film hangers. These film hangers are then placed into the tank and allowed to remain for approximately five minutes at this temperature; as the solution grows older, it will take longer. The tanks are made to accommodate different numbers of hangers, being furnished in sixes and twelves, and if you have that number of films to develop, all may be placed in at one time.

During the period of development, it is advisible to lift the hangers up frequently to insure an even action of the developer and avoid their becoming stuck together.

It is advisable to make this operation as nearly mechanical as possible, allowing them to remain in the developer for the prescribed length of time, as it is a matter requiring some experience and a sense of judgment to know just when a negative is thoroughly developed by looking at it under the ruby light. Should a question of this kind arise, the best method to follow is, to remove the hanger with film to the ruby light and determine whether or not the yellow unoxidized emulsion in the PLATE MAKER CORNER is still a lemon-yellow, or has begun to turn a gray smoky color. A gray smoky color is an indication that the film is thoroughly developed and has begun to fog. This is true when the temperature of the developer is correct (65 per cent).

When development is complete, remove the film hanger without detaching the film and rinse in water as nearly the same temperature as that of the developer as possible and place into the hypo bath. It is advisible also to have the hypo bath as nearly the temperature of the developer as possible; under no circumstances should the hypo bath be above 75 degrees.

After having properly fixed as indicated under the special FIXING on page 219, wash for 15 or 20 minutes in running water and hang up to dry. It is not necessary to remove film from hanger during any part of this process, and once it is loaded into the hanger, allow it to remain until developing, rinsing, fixing and drying it complete.

The fixing bath used in this method is the same as that used in the tray method, and the formula is furnished elsewhere in the text. A special tank for the fixing bath to be used with this method is similar to the developing tanks in size, but differing in composing.

During the hot summer months a special hardening bath is of use when the wash water is above 75 degrees. This special bath hardens the emulsion to a far greater degree than the hypo bath alone will do, and will eliminate much trouble in cities where the water is above this temperature. This will prevent the emulsion softening while the films are washing so that they may be handled with ease and keep the emulsion on the film base. If this is to be used, provide yourself with an extra tank and set it between your developer and fixing tanks. After the films have been thoroughly developed, rinse them and then place into this special hardening solution, allowing it to remain from three to five minutes, then take it out, rinse again and place into the fixing bath and proceed in the usual manner.

FORMULA FOR SPECIAL HARDENING

(To be used when the wash water is above 75 per cent

Chrome Alum, 1 lb.; Water, 1 gallon.

This solution may be used over and over again until it begins to show a muddy precipitate. It is necessary when this is used that the film be cleaned with a piece of cotton after it has been removed from the washing tank, just prior to drying.

DEVELOPER FORMULA

(Tank Method)

Water	6 gallons
Elon	1 oz., 369 grains
E. K. Co. Sulphite of Soda	40 oz.
Hydroquinone	7 oz., 145 grains
E. K. Co. Carbonate of Soda	40 oz.
Potassium Bromide	320 grains

Mix the chemicals in the order named, dissolving each before the other is added.

This same formula can be purchased already mixed ready to add the required quantity of water.

DEVELOPING X-RAY FILMS

As the new X-Ray films recently perfected by the Eastman Kodak Company are duplitized (that is, coated on both sides), it is not necessary to look for the emulsion side either in loading or developing. If developed in the tray care must be taken not to scratch them and use a little

more developer in the tray than you would for plates so as to allow them to float as much as possible.

We have found in using these films that a standard time developer is the best, as it is otherwise very hard to judge when they are finished. The time for development is reduced about twenty-five per cent over that of the X-Ray plate, because the same amount of emulsion is spread over both sides of the plate instead of upon one, therefore, making it thinner and allowing the developer to penetrate more rapidly. In using the developer formula herein given, it will require about three and a half minutes to develop a normally exposed X-Ray film.

The developing tanks and loaders advised to be used with duplitized X-Ray films will appeal to the busy Roentgenologist. They minimize the work, are absolutely reliable and give uniform results.

The many advantages of films over plates will readily appeal to you, but we must impress upon you the extreme caution necessary in handling while loading and developing.

DEVELOPING DENTAL FILMS

Dental X-Ray films are prepared with two films in each capsule, or envelope, one intended for the patient and the other for the dentist. They are to be developed in the regular manner until the object appears the same on both sides. Wash and fix as usual.

If some identification mark is needed to distinguish different films, a very simple method is to use a soft lead pencil mark on the emulsion side of the film before it is

developed. Mark close to the edge on the narrow ends to avoid interfering with the important part of the film.

A developing tank for dental films is a great advantage if you are doing considerable of this kind of work. The regular dental developing tank as supplied by the E. K. Co., will hold eight pairs of films at a time. Your assistant can handle the work with this method very readily, as it converts it into a mechanical operation.

DEVELOPER FORMULA

Solution A—Water, preferably distilled	1	gal.
Metol or substitute	1/4	oz.
Hydroquinone	4	oz.
Sodium Sulphite	7 1/2	oz.
Solution B—Water	1	gal.
Sodium Sulphite	7 1/2	oz.
Sodium Carbonate	10	oz.
Potassium Carbonate	5	oz.
Potassium Bromide	3/4	oz.

By warming the water, not to exceed 120 degrees, it is much easier to dissolve the chemicals; see that each is added in the order given and also that each is thoroughly dissolved before adding the next.

This formula has been found to give the maximum of results in our laboratory work, and we can recommend it to you. When the solutions are kept separately, this formula will keep a considerable time.

Use equal parts of solutions A and B; do not mix until ready to use. The temperature should range from 65 to 70

degrees while using. For the normal exposure it will require about four minutes to develop.

FIXING BATH OR HYPO

Because of the heavy emulsion on X-Ray plates we have found that the chrome alum bath is the best adapted for our work, as it hardens the gelatine to a greater degree than the most commonly used acetic acid hardener. Nevertheless, hypo fixing salts, which you can buy at any photo supply dealer, will answer the purpose. Simply dissolve them in the given quantity of water.

The acid fixing bath does two things in fixing the plate; first, the hypo-sulphite of soda dissolves the unoxidized silver bromide from the emulsion, making it a soluble salt of silver and rendering the plate transparent. A plate is only one-half fixed when the yellow milky color disappears. To remove plate then and wash and dry it will give rise to stains later. Secondly, the chrome alum of the bath hardens the gelatine emulsion, making it firm and adhesive to the plate. When the emulsion is hard and set it will dry more quickly and is less liable to be scratched.

Hypo bath is cheaper than ruined plates. **Keep your bath fresh and clean to obtain best radiographs.** Do not add new hypo bath to one partly used.

When the hypo fixing bath will not clear the plates in five minutes throw it out and make up new. When not in use, keep your fixing bath covered to keep out dirt and prevent evaporation.

HYPO FIXING BATH FORMULA

Solution A—	Crystal hypo	4	lbs.
	Water	120	oz.
Solution B—	Chrome Alum	4	oz.
	Sodium sulphite (dried)	8	oz.
	Water	60	oz.
Solution C—	Sulphuric acid, C. P.	½	oz.
	Water	20	oz.

Mix each subdivision separately, then add C to B and thoroughly mix before adding to A. Have C and B cold before mixing. Any photo supply dealer can prepare this formula for you if you have not your own chemicals.

INTENSIFICATION

By this method it is possible to build up a thin, under-developed plate to a great degree, and an underexposed plate to a point where it is possible to make a reading. The under-developed plate will show a very marked improvement, while the underexposed plate not quite so much, but in a great majority of cases you can save yourself the expense, time and inconvenience of making the radiograph over.

This is a chemical process that will increase the density of the silver oxide in the emulsion and make the lines of demarcation more visible. Before the process is begun, however, it is imperative that all traces of hypo be washed out of the plate. Wash for an additional fifteen or thirty minutes and while your emulsion is still wet, place in Solution A.

Solution A is known as the bleacher and your plate should be left in it until the image all but disappears and a heavy white coating is formed on the emulsion. The operation may take from five to fifteen minutes. Rock the tray continually during the operation. When finished, rinse thoroughly and place in Solution B.

When placed in this solution the image will gradually blacken and should be left here until it is of an even color all over. This should not require more than five minutes.

Examination before the light will now reveal a greater density than the original negative, making it now possible to see the lines of demarcation. After intensification, the negative must again be thoroughly washed before drying.

It is understood, of course, that intensification should only be used when you have a noticeable image to begin with as a base. This entire process is performed under a white light.

INTENSIFIER FORMULA

Solution A—	Bichloride of mercury.......	120 gr.
	Potassium bromide.........	120 gr.
	Water	16 oz.
Solution B—	Sodium sulphite............	2 oz.
	Water	16 oz.

Keep in dark bottles; mark solution **"poison."**

To use:—Bleach with Solution A. Rinse and place in Solution B to blacken.

REDUCTION

An over-exposed plate which is so dense that it cannot be read may in the majority of cases be reduced by this method so that it is readable.

First, be sure that all hypo is washed out of the plate by giving it an extra washing of fifteen to thirty minutes. Place in the tray of solution while the emulsion is still wet. Keep the tray rocking until the reduction is sufficient to enable you to make a reading. The time will vary according to the density of the plate and the amount of reduction desired, usually requiring five to twenty minutes.

If only a local reduction is desired after the plate is thoroughly washed supply the solution repeatedly with a tuft of cotton to that part only.

When this operation is completed it will be necessary to wash the plate again for about thirty minutes in order to remove all chemicals and insure safe-keeping.

The formula given below is similar to that which you may buy put up in sealed tubes from any photo supply dealer.

In making up this formula if the two solutions A and B are kept separately and in dark bottles, there will be no appreciable deterioration. This is not true, however, after they are mixed ready to use.

REDUCER FORMULA

Solution A—	Potassium ferricyanide.......	1 oz.
	Water	16 oz.
Solution B—	Crystal hypo................	1 oz.
	Water	16 oz.

To use, mix one ounce of Solution A with eight ounces of Solution B. This operation is performed under a white light. Wash the tray well after finishing, using a little Sapolio to scour.

STORAGE OF PLATES AND MATERIALS

X-Ray plates must be kept in a cool, dry place with the boxes on edge and not lying flat. Do not store near radiators or steam pipes; you will have defective plates if you do. Dampness or any form of moisture is equally bad for plates. Do not have them in a room where there is gas burning for any length of time, or near new paint, or the vapor of turpentine. We cannot impress on you too strongly the extreme sensitiveness of the plates, as to both light and chemicals. Plates kept on edge and in a cool, dry place will keep for a year without deterioration.

As the X-Rays will penetrate, a distance from 60 to 80 feet from the tube, plates must either be kept at a greater distance than this or in a lead-lined cabinet. The ordinary wall is no protection to the plates when the tube is being used, as X-Ray plates can be fogged through several walls.

All chemicals must be kept in tight containers, as they absorb moisture from the air, which causes deterioration. Ready prepared formulas come in waxed paper or glass containers so that they will keep under any ordinary conditions.

DARK ROOM EQUIPMENT

The room to be used as a dark room should be located where running water is accessible and where good ventilation is permissible. The size of the room needed will depend somewhat upon the amount of work handled. For the average Chiropractor I should say a room 6 x 8 would suffice. It must be absolutely dark, not allowing the faintest trace of light to enter through cracks, pinholes or around curtains. The least conceivable rays of light will, if allowed

to strike a plate, cause fog. I have seen dark rooms which were not more than 6 feet square built inside the X-Ray operating room, artistically finished on the outside and lined with black building paper on the interior. These proved to be practical and convenient.

It should be arranged to have one table for developing, one for plate loading and one for the fixing bath; have the fixing bath nearest the sink. Do not have any unnecessary shelves or tables, as the dark room is a place where rubbish will accumulate very rapidly. It should at all times present the same tidy appearance as your other offices. When you work in here, you do so as a chemist, for all the dark-room operations are but chemical processes. The chemist never allows dirt to accumulate; never uses dirty utensils; never allows any spilled chemicals to remain on tables, scales or floor. You must do the same.

Probably the most important part of your dark-room equipment is the ruby light. As a majority of ruby lights are not safe, be positive that you have a safe one and you may test it in this manner: Place an unexposed plate under the light (emulsion up) the same distance that you would do your developing; lay a coin or piece of metal on it, and leave exposed for five minutes. Now, develop the plate, and if any outline of the object shows on the finished plate, your light is unsafe.

Never use any metal containers for mixing your solutions; use a glass graduate or bottle. Steel enameled trays are the most durable of all, while glass or fiber are as suitable. Four trays should be the correct equipment for your work. You should have two graduates, a 32-oz. and a

smaller one; a hard rubber stirring rod and dark colored bottles with stoppers to keep the solutions in.

Many forms of developing tanks are on the market and any of the standard quality are suitable if you desire to use this method. Entirely satisfactory results may be obtained with the tank method, providing the temperature can be controlled. Our only advice, however, about this method would be to use a metol-hydroquinone developing formula. It has been our experience in the P. S. C. laboratory that the shadows and finer details of spine work are best shown by the above developer, while pyro developer is very contrasty and oxidizes quickly.

The most convenient method for taking care of your fixing bath is to obtain a regular fiber fixing box made for that purpose. Your solution can be kept until used up if covered when not in use.

A plate washer in which the plates can stand on edge and the water allowed to flow through them will wash your plates quickly and easily and occupies very little space.

A drying rack will enable you to dry your plates more quickly and evenly and it should be up away from any dust. As these are inexpensive you cannot afford to be without one.

Photo supply dealers are now selling a fibroid cloth, black in color and similar in appearance to oil cloth. This is intended for covering tables, trays and making aprons. It is acid and alkali proof and is an excellent article for these purposes.

DARK-ROOM "DON'TS"

1. Don't give your plates to a photographer to develop unless he has had special instruction in developing X-Ray plates, for he will be guided by the method used in ordinary photographic developing and your plates will be underdeveloped.

2. Don't use old, weak developer, for its cost is nothing compared with the cost of a plate. The developer commences to oxidize as soon as it is mixed and unless kept on ice or in a very cool place, will not keep over from one day to the next.

3. Don't rub your fingers over the surface of the plate while it is developing.

4. Don't put the hands into the hypo and then back into the developer, for a few drops of hypo solution in the developer will absolutely ruin it. Wash the hands well and then dry.

5. Don't use a tray for hypo one day and for developer the next. Mark your trays and use them for the same solution each time.

6. Don't strengthen old weak hypo with some new. Throw it out and make another batch.

7. Don't turn on your white light until the plates have been in the fixing bath for at least three minutes.

8. Don't remove the plates from the fixing bath to wash for at least five minutes after they become clear.

9. Don't hold your plate to a bright light for examination until the hypo bath has removed all milky appearance.

10. Don't load plates just after mixing or weighing chemicals in your dark room.

PLATE OR FILM TROUBLES

Ninety-nine per cent of plate defects are due directly to careless manipulation in the dark room.

Fog, a smoky appearance; due to unsafe ruby light, too long in the developer, the plates not being properly stored, or chemical dust while loading.

Flat negatives, having little or no contrast, may be due to any of the following: under-exposure, cold developer, under-development, or exhausted developer.

Pinholes, or round, transparent spots, are due to air bells. These form the second the plate is put into the developer, and may only be overcome by vigorously shaking or rocking the trays. These occur more frequently in the tank method.

Hypo, or other chemical rust, may settle on the plate during loading and cause either transparent or dark spots.

Small dark spots are usually caused by using envelopes on which some developer has been spilled or by water spattering on the plates before developing.

Streaky plates may be caused by improper, uneven drying, by rocking the tray in one direction only during development, or a hypo solution that is old and exhausted.

Stains—milky streaks may be due to insufficient washing wherein all hypo is not moved; this usually appears two or three days after being dried.

Yellow stains usually due to old developer, or hypo developer.

Greenish stains due to too warm a developer.

Bluish, almost metallic luster, prolonged over-development causing a deposit of metallic silver.

Abrasion marks, caused by rubbing the surface of the plate while loading or careless handling afterwards.

Crescents, white streaks or lines appearing on a film are due to improper handling; never bend a film when loading, as this is the cause of most white streaks in films.

PART VII

PLATE READING FROM A CHIROPRACTIC STANDPOINT

Plate reading is a science in itself, and is one that requires a great deal of study and practice. It differs very much from the work you are going through every day in palpating your cases. In plate reading you use your eyes, while in palpation you are developing the sense of touch, so that you may determine laterality, inferiority and superiority by comparing one spinous process with those above and below. In plate reading we not only take into consideration the spinous processes, but also the transverse processes, the articulating processes, the upper and lower edges of the body of the vertebrae and the spaces found between the bodies of the vertebrae.

When you begin the study of plate reading, do not attempt to see how fast you can read them, or how many you can read in a given length of time, as this is work that requires careful study and judgment and you must take time to become accurate in making your listings.

In teaching this work, I am preparing a foundation, and it is upon this foundation that you must build. Every day we have plates to read that present a new and interesting condition; something that must be carefully studied. There are none of us who can claim to be thoroughly proficient in this work because of the new conditions presenting themselves for our study and analysis. That is why we must train our eyes, and this will take a great deal of practice. Try, if possible, to learn these rules by heart, so

that when you are reading plates it will not be necessary for you to stop and glance at the book and look up rule one, two or three, in order to make a listing. Get them firmly impressed in your mind; then you have them always ready to build upon. In your own practice, you may have plates sent you from some other practitioners for reading. You must be absolutely sure of your reading before you send your plates back to them. That is why I want to impress upon you the necessity of absolute care.

The first rule I have prepared for plate reading is the placing of the plate or film in the reading box. The emulsion side of the plate should be nearest the light and the glass side of the plate away from the light. I have made it a rule in taking spinographic plates to place a marker upon the right side. You will find that this marker is on every spinographic negative and should always be at your right when you are reading the plate; then you are sure of your direction. The reason for having this marker on the right side, and this side only, is that sometimes mistakes will be made in placing these plates or films in the envelopes and holders. Then you will find upon reading that the emulsion will be away from the light, but the marker is still upon the right side, and you are sure that this plate should be read with the emulsion side away from the light. In brief, the marker should always be to your right.

When using Films, it is absolutely necessary that a marker be used as they have emulsion on both sides, so that it is impossible to tell which is right or left without a marker. Rule No. 2 is to determine an imaginary median line of the spine and compare the spinograph shown upon the plate with that imaginary median line. The question

arises, where do we find this median line? I refer you back to your freshman work, where you were taught the normal spine, the normal articulation of one vertebra with another, and it is here that you should have obtained a mental picture of a normal spine. If you did not have this mental picture you could not have developed your palpation. In every case you palpate you must compare your findings with the normal spine which you have in your mind's eye. Here we compare the spine shown upon the plate or film with the normal or imaginary median line that we have in the mind's eye. It is your mental picture, then, which determines the median line.

Rule No. 3 is to locate the first Dorsal Vertebra. To do this always look for the large transverse processes directly above the first pair of ribs, or to which the first pair of ribs are attached. This rule is given for the purpose of making a correct count of the vertebra. If you have a plate showing the lower cervical and upper dorsal vertebra you begin by deciding upon the first dorsal and either counting up or down from it.

Sometimes you will find large transverse processes upon the seventh cervical vertebra; do not mistake these for the transverse processes of the first dorsal, as these you will always find above the first pair of ribs. You will note that the first pair of ribs does not extend out very far from the spine, as they curve around the clavicle. You will notice that the transverse processes of the first dorsal vertebra are usually larger than any of the rest in the spine and tilt to the superior, while large transverse processes on the seventh cervical vertebra invariably tilt toward the inferior.

Rule No. 4. To determine the laterality of the dorsal or lumbar vertebrae: In determining laterality we do not only consider the spinous processes, but we also take every part of the vertebra into consideration. In palpation you compare the spinous processes. The bodies of the vertebra are too deep for you to palpate. In spinography you not only consider the spinous processes, but you consider also the body of the vertebra itself, the transverse processes, articulating processes, the laminae and the spaces found between the bodies into consideration when making a listing. The first part of the rule in determining laterality is to compare the center of the spinous process in question with the ones above and below. After making this comparison with the vertebra in question suppose we say that we have found the center of the spinous process to the right of the ones above and below it; our next step, then, is to measure the distance from the center of the spinous process to the edge of the body of the vertebra, and we find that the distance is greater from the center of the spinous to the left edge of the body, and it is nearer to the right edge of the body, proving, therefore, that the spinous process is subluxated to the right.

In locating our point for comparison, we do not take the tip of the spinous process as we do in palpation, but always look for the center of the laminae, which is the center of ossification for the spinous process. After finding this center, we then make our measurements from it to either edge of the body. In finding the outer edges of the body of the vertebra we look for the heavier white line, or the line which is slightly concave. Be very careful not to mistake the lower edge of the transverse processes for the edge of the body, as this shadow is always a little

darker in shade. After determining the laterality, we take the tip of the spinous processes into consideration to determine whether or not it is bent. This because it is from this rule (measuring the distance from the center to each edge of the body) that we can determine a bent spinous process. First, we find the center of the spinous process; then measure to each edge of the body, and make our listing of the laterality. If we find the center of the spinous process nearer the right edge of the body and farther away from the left edge of the body, but the tip of that same spinous process is nearer the left edge of the body and farther away from the right, it would be listed as a right subluxation with a spinous process bent to the left. Bent spinous processes are also determined by comparing the centers of the same with the tips, or drawing a line from the center to the tip of the process. If the tip is found to be right or left of its own center, it should be listed as a bent spinous process whether subluxated or not.

It is well to remember that in the middle and lower dorsal vertebrae the spinous processes overlap the bodies below and sometimes in the lumbar region as well, so you must be careful in finding the spinous process of the vertebra in question in these regions.

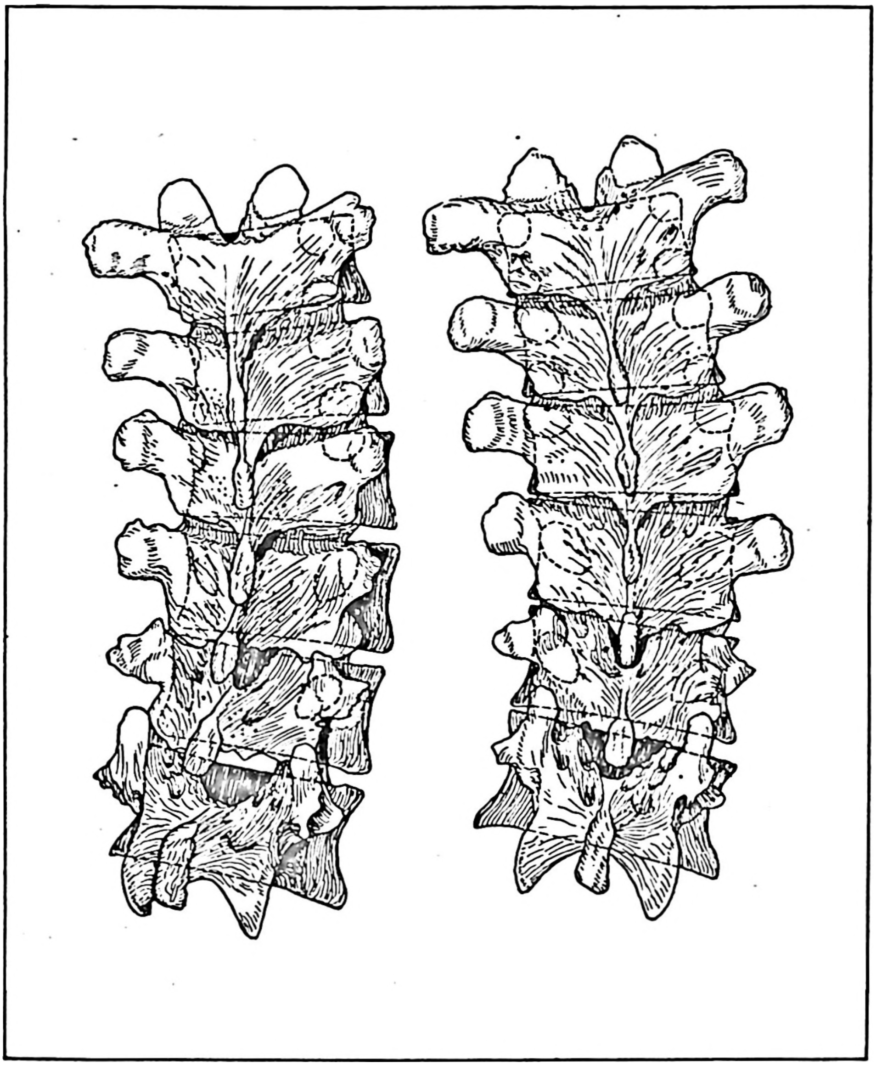


Figure 34

Right Rotatory Scoliosis   Right Scoliosis

Rule No. 5 considers the rotatory scoliosis, and it might here be mentioned that a rotatory scoliosis is usually a hard condition for the student to comprehend.

To determine whether or not we have a rotatory scoliosis, we find the direction of the scoliosis and then measure the distance from the center of the spinous processes to the edges of the bodies, the same as in determining laterality. It takes three or more vertebrae to produce a rotation, or a rotatory scoliosis. When we speak of a rotatory scoliosis we mean there is a curvature produced by the bodies of the vertebrae being rotated. In a scoliosis to the left we may find that the spinous processes are to the left of our imaginary median line, but if the spinous processes are nearer the right edge of the body of the vertebra, we would list the vertebra in question as being a right subluxation, providing the (spinous process) is to the right of a line between the center of the spinous process of the vertebra above and below it. It does not necessarily mean that all vertebrae are subluxated, when the spinous processes are found nearer the right or left edges of the bodies of the vertebrae as rotations show them. We will find many rotations without any subluxations, due to the fact that all of the spinous processes are in alignment with one another and the articulations of these vertebrae have not been interfered with. We must, in all cases of rotation, compare the center of the spinous processes with the one above and below, determining whether or not it is to the right or left of the one above and below it, to accurately determine the subluxations existing within the rotation.

You will also find that the left articulating processes in a rotation of this kind show much ~~larger~~ and plainer than

smaller

the right articulating processes, due to the fact the left side is rotated nearer the plate.

Our listing in a case of this kind would be spinous processes to the right, bodies rotated to the left, or a left rotatory scoliosis.

Briefly, if the bodies of three or more adjacent vertabrae are rotated in the same direction with a lateral bending of the spinal column in their location, it constitutes a rotatory scoliosis. In our listing we use the terms rotatory scoliosis and rotation synonymously.

To differentiate between a lateral scoliosis and a rotatory scoliosis, you will find that in the former the spinous processes as compared with the median line of their bodies are in the same direction as the curve of the spine. In the latter the spinous processes are to the right or left, as the case may be of the median line of the vertebrae themselves, while the bodies of the vertebrae are rotated opposite to the direction of the spinous processes, but in the same direction as the laterality of the curve. This means that the spinous process would be to the right of the median line of the bodies of the vertebrae in a left rotation and to the left in a right rotation.

Rule No. 6. To determine superiority and inferiority: First draw a line, by using a straight edge, from the tip of one transverse process to the tip of the opposite transverse process of the vertebra in question. This is to determine whether the left or right transverse process is higher or lower on the side of the laterality. Next, we place the straight edge along the upper and lower edges of the body of the vertebra to determine whether or not the body is

tipped in the same direction that we have found the transverse processes. We then consider the articulating processes in the same manner, and if we have found that they conform to the tilt of the transverse processes we know that we have a subluxation either superior or inferior, and not a bent transverse process. You will find bent transverse processes the same as bent spinous processes. Also compare the articulating spaces between the vertebra as these spaces will show larger on the side of laterality and superiority and smaller on the side of laterality and inferiority. After determining whether or not we have inferiority or superiority, we add our findings to the laterality which we assume has been listed.

Rule No. 7 deals with laterality in the cervical region. In the cervical region, with the exception of the atlas, our laterality is determined by finding the center of the spinous process and comparing this center with the center of the one above and the center of the one below it.

The spinous processes in the cervical region, with the exception of atlas and seventh cervical, are bifurcated, but we cannot always depend upon these centers of bifurcation as the processes are found to be bent, the same as spinous processes of other regions. We must find the center of the spinous process by locating that point at which the laminae are joined to form the spinous process. We can measure the distance from this center to the outer edge of the body of the vertebra in question, the same as is done in the dorsal and lumbar regions. The edges of the bodies in the cervical region are found by looking for the articulating processes, and it is found that these edges are directly below them. Some of the prongs of these bifurcations are

also longer than others, and these should be mentioned in your listing to account for possible errors in palpation. Find the center and work from that.

The superiority and inferiority in this region is determined in the same manner as in the dorsal and lumbar regions.

Rule No. 8 determines the laterality of the axis. First, find the center of the spinous process, comparing or lining it up with the center of the odontoid process. If we find it to the right or left of the odontoid process, then measure the distance from the center of the spinous process to the outer and superior margins of the axis to prove our first finding. To determine superiority or inferiority, place a straight edge on the outer superior margins of the axis lining up one side with the other. If we find it to be higher on the side of laterality, list it superior. If found lower, list it inferior.

Rule No. 9 deals with the atlas. The atlas being the most difficult one of the vertebrae to list, there are several rules that must be closely followed. First, when the exposure is taken of this region, you must be very careful in placing the patient's head. Make sure that the head is lying straight and is not tipped, either right or left, up or down. The head must be level in order to make an accurate comparison with the surrounding structures. In other words, the face should be level. Second, we must always consider subluxations of the axis before attempting a listing of the atlas, as a tipped axis will mislead us if we fail to consider it first. Third, have a picture in mind of the normal articulation between the occipit, atlas and axis.

To determine laterality of the atlas after applying the above rules, our first step will be to compare the outer edges of the lateral masses with the outer edges of the body of the axis. This is in order to find whether or not the lateral masses are to the right or left of the outer edges of the axis. After making this comparison, we next consider the spaces found between the inner edges of the lateral masses and the outer edges of the odontoid process. Next we consider the distances from the outer border of the lateral masses of the atlas to the descending ramii of the jaw, providing both ramii show the same upon measurement. Also observe the distance from the tip of the transverse process to the ramus of the jaw. Do not attempt to list an atlas by any one part of this rule, as they must all be used collectively.

To determine superiority and inferiority of the atlas, observe the space found between the articulating surfaces of the axis and the lateral masses of the axis; also use a straight edge from one lateral mass to the other and from one transverse process to the other, as in some cases you will find the atlas and axis both subluxated, and these spaces will not change. By using a straight edge from one lateral mass to the other, as well as the transverse processes, we are able to determine whether or not the transverse process is bent, as will sometimes be the case. We must also consider the horizontal plane of the atlas with the vertical plane of the occiput and the median line of the spine. Example: If we find the atlas is subluxated to the right, the right lateral mass will be slightly to the right, of the right, upper and outer edge of the axis. The space between the right lateral mass and the odontoid

process will be greater than the space on the left of the odontoid process. If the ramii of the jaw appear to be the same width upon measurement, we will find that the right lateral mass will be near the ramus of the jaw on this side. If we should find that these ramii vary in width, do not use them to determine any laterality, as it indicates that the jaw was tipped a little to the right or left when the patient opened the mouth to have the plate taken.

If the atlas is superior on the right side, you will find upon using your straight edge that this right lateral mass is superior to the left lateral mass, and the space between the atlas and the axis will be greater than the space on the opposite side. We will also find that the right transverse process will be higher than the left transverse process.

Our listing, then, for the atlas would be, right and superior. The posteriority of the atlas must be determined either by palpation or by taking a lateral view of the cervical region. Views of this type also reveal inferiority and superiority, posteriority and anteriority. If we find that the spinous processes are tilted downward, or inferior, we will find the body of the vertebra tilted to the superior or inferior. This view will also show a dislocation, fracture, exostosis and ankylosis much better and clearer than an anterior to posterior view.

Rule No. 10 is for listing subluxations of the ilii. To determine subluxations of the ilii, note the articulation of the same with the sacrum. If we find the ilium superior to this articulation with the sacrum, list it accordingly. In the majority of cases, you will find that the pelvis is tipped higher on one side than on the other, while the articulation remains normal. This tipping would indicate that it is

Figure 35—A Corner of The P. S. C. Spinograph Laboratory No. 2, with a Class of Plate Reading in Session

adaptative to a scoliosis or rotation some place in the spine, or to a condition where one limb is found to be shorter than the other. Subluxations of the ilii, superior and inferior, are very rare, but you will find them subluxated posteriorily, which is determined by palpation.

Rule No. 11 is for listing subluxations of the coccyx. To determine subluxations of the coccyx, we must have a plate that covers the pelvis, showing whether or not the coccyx extends to the right or left of an extended line drawn through the center of the sacrum. This of course will only show laterality. The posteriority or anteriority must be determined from palpation.

Rule No. 12. Always be very careful when reading plates that you do not fail to observe any abnormal conditions other than just the subluxations, as you may find exostosis, ankylosis, fractures or tubercular conditions, lateral curvatures and rotations.

Rule No. 13. In listing the cervical, dorsal or lumbar vertebrae, the student or practitioner is admonished against trying to list a subluxation by using just a part of the above rules, as they all must be taken into consideration in order to make a correct listing. Remember that anterior-posterior views only show laterality, superiority and inferiority. The posteriority is determined from palpation unless you have a lateral view of the spine.

Rule No. 14 is to impress upon the mind of the parties listing spinograph plates or negatives that he cannot pick majors from just the negative alone. To do this, he must use the symptoms found, as well as palpation and nerve tracing to accurately determine his major.

RULES FOR PLATE READING

1. Place the plate or film in the reading box with the plate marker on the right side, as this marker is always placed upon the right side of spinograph negative when making the exposure.

2. Determine an imaginary line of the normal spine and compare that with the abnormal spine pictured upon the negative.

3. To determine the first dorsal vertebra, look for the large transverse processes to which the first pair of ribs are attached. This gives a landmark whereby you may obtain a correct count of the vertebrae.

4. To determine laterality of the dorsal or lumbar vertebrae, we must take into consideration every part of the vertebrae, viz., the following: First, compare the centers of the spinous processes with the ones above and below; to prove whether it is lateral, measure the distance from the center of the spinous processes out to the edge of the body of vertebrae. In finding the center of the spinous process, seek the point where the laminae meet to form the spinous process.

If we find that the center of the spinous process is nearer the left edge of the body, with the tip of the same spinous process nearer the right edge of the body, we would have a left subluxation, with a bent spinous process to the right. The tip of the process might be defined as the inferior point showing upon the vertebrae. A bent spinous process is also determined by comparing the tip of the process with its own center, determining whether it is

bent to the right or left of its own center and listing it accordingly.

5. To determine a rotary scoliosis, we first measure the distance from the center of the spinous processes to each edge of the bodies of the vertebrae, as in the above rule. If we find that the spinous processes are much nearer the right edges of the bodies than the left, it would then be determined that we have a left rotation of the vertebrae or vice versa.

We always find that a rotation takes in three or more vertebrae, which fact produces the scoliosis. Even though we find that the spinous processes are to the left of our imaginary line of the individual bodies, but that the spinous processes are nearer the right edges of the bodies of the vertebrae, we would list them as being right, but not necessarily right subluxations, as they may be in alignment with one another. You will also find that the left articulating processes in a condition of this kind will always show much larger and plainer than the right articulating processes, due to the fact that the left side is rotated nearer the plate. To differentiate between a lateral scoliosis and a rotary scoliosis, we will find in the first listing that the bodies of the vertebrae, as well as the spinous processes, are all to the left, or right, as the case may be, of the median line of the spine; while in a rotary scoliosis, we will find the bodies rotated left, or right, forming a curvature, but the spinous processes would be to the right in a left rotation, and to the left in a right rotation.

6. To determine superiority or inferiority, observe whether or not the transverse processes are level by using a straight edge from one to the other. Also observe the

angle of the upper and lower edge of the bodies to see if they correspond with the angle formed by the transverse processes. Also use the articulating processes in the same manner, as this will prove that the subluxation is either superior or inferior and not an illusion produced by a bent transverse process. We next consider the spaces between the vertebrae, both above and below. We cannot use any one point of this rule separately to determine superiority and inferiority. Use each one given, adding the findings to the laterality, which has already been determined.

7. In the cervical region, with the exception of the atlas, determine the laterality by comparing the center of the bifurcation with the one above and below, measuring the distance from the center to each edge of the body to prove our first findings, as given in a previous rule. Superiority and inferiority in this region are found in the same manner as in Rule 6.

8. To list the subluxations of the axis first compare the center of the spinous process or center of ossification with the center of the odontoid process, determining whether or not the center of the spinous process is to the right or left of the odontoid process, then measure the distance from the center of the spinous process to the outer superior margins of the axis to prove our first findings.

9. The axis being the most difficult to list, there are several points that must be closely followed.

A. In taking an exposure of the atlas, the head must be straight in order to make an accurate comparison with the surrounding structures.

B. Subluxations of the axis must be taken into consideration when listing an atlas.

C. Have a picture in mind of the normal articulations between the occiput, atlas and axis.

To determine laterality of the atlas, after applying the above rules, compare the outer edges of the lateral mass with the outer edge of the axis to find whether or not the lateral masses are right or left of the axis. Also compare the spaces between the inner edges of the lateral masses and the odontoid processes. Also measure the distance from the outer border of the lateral masses of the axis to the descending ramii of the jaw, and observe the transverse processes to determine whether they are to the right or left of the ramii of the jaw. Always measure the width of the ramii first before using this part of this rule.

To determine superiority and inferiority of the atlas or axis, observe the spaces between the articulating processes of the axis and the lateral masses of the axis, also using a straight edge from one lateral mass to the other and from one transverse process to the other, as in some cases in which the atlas and axis are both subluxated, there will be no difference in the spaces between the articulating surfaces of the atlas and axis. Also compare the horizontal plane of the atlas with the vertical plane of the occiput, and the median line of the spine.

Example: If we find that the atlas is subluxated to the right, the lateral mass on the right side will be slightly to the right of the edge of the axis. The space between the lateral mass and the odontoid process on the right side

will be greater than the space on the left side. The right lateral mass will also be nearer the descending ramii of the jaw, providing both ramii show the same width upon measurement. If tipped superior on the right side, the space between the axis and atlas will be greater than that on the opposite side. We will also find the right lateral mass and transverse process higher than on the left. We will then list the atlas as being right and superior.

Posteriority is determined by palpation or by taking a lateral view of the cervical region. This view also reveals inferiority and superiority by judging the distance between the spinous processes, and the angle formed by the body and the spinous processes.

Example: If we find the spinous process tipped downward and much closer to the one below than the one above, you will find that the body of the vertebrae will be tipped upward, indicating an inferior subluxation and vice versa, but never attempt to make a reading of a lateral view until you have first taken the anterior-posterior view. This gives you a double check upon your listing of the lateral views. This view will also show a dislocation, fracture, exostosis and ankylosis much better and clearer than an anterior-posterior view.

10. To determine a subluxation of the ilii, note the articulations of the same with the sacrum; if we find the ilium superior to its articulation with the sacrum, list it accordingly; but if we find that the pelvis is tipped higher on one side than the other, and the articulation normal, it would indicate that the tipping is adaptative to a curvature of the spine, or a condition in which one limb is shorter than the other.

11. To determine subluxations of the coccyx, note whether it extends to the right or left of an extended line drawn through the center of the sacrum.

12. Always be on the lookout for other abnormal conditions, as you may find exostosis, ankylosis, curvatures, fractures, caries or tubercular conditions, etc.

13. In listing the cervical, dorsal or lumbar vertebrae, the student or practitioner is admonished against trying to list a subluxation by using only a part of the above rules, as they all must be taken into consideration in order to make the correct listing.

Do not attempt to list majors from a spinograph negative, unless you have all symptoms, have palpated the case and made a nerve tracing.

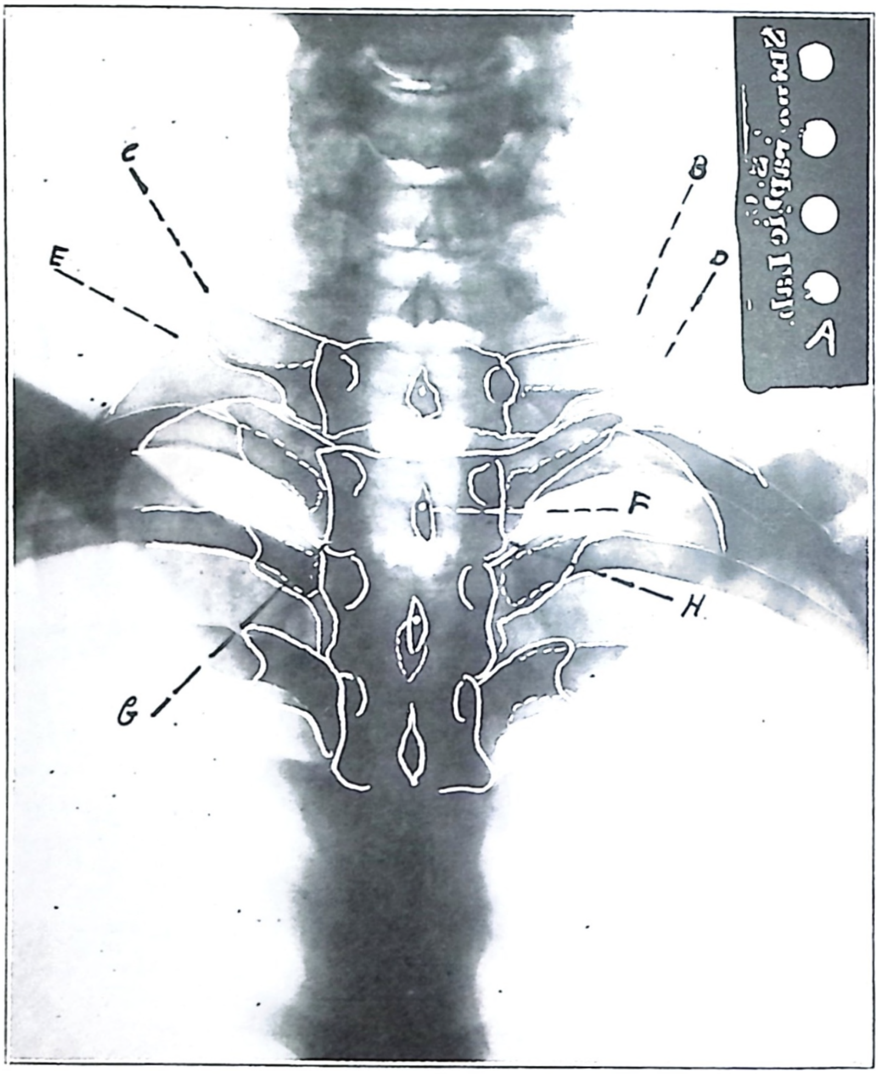


Figure 36

RULES AND READING OF FIG. No. 36

Rule No. 1—

Letter A shows position of number plate when placed properly in reading box.

Rule No. 2—

The imaginary median line in reality is the picture you have in mind of a normal spine, with all spinous processes directly in line with one another.

Rule No. 3—

Letters B and C represent the transverse processes of the first dorsal vertebrae, which are directly above letters D and E, which represents the first pair of ribs.

Rule No. 4—

Letter F represents center of spinous process of second dorsal vertebrae, G and H representing the outer edges of the body.

To determine the laterality compare the center of the spinous process F with the one above and below, then measure from center of spinous process F to edge of body G and then make the same measurement between F and H, the side having the lesser distance, which is H in this case, shows it to be a right subluxation.

Our spinographic listing would be as follows:

2nd Dorsal R.

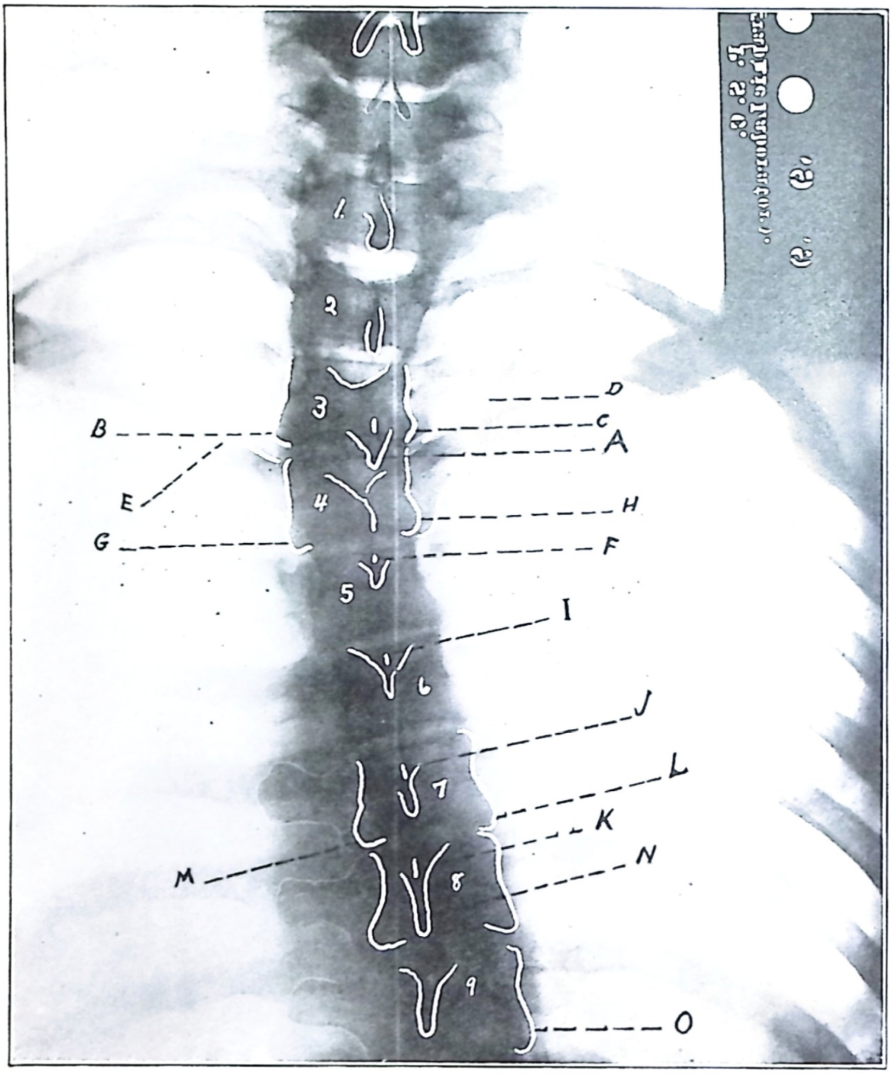


Figure 37

RULES AND READING ON FIG. NO. 37

Rule No. 5—

Letter A represents spinous process of the 3rd dorsal vertebra.

Letters B and C outer edges of the body.

Comparing the center of the spinous process A with the one above and below, we find it to the right, then measuring the distance from the center of the spinous process A to the edges of the body B and C, we find the distance between A and C would be less than from A to B; so we have proven it to be a right subluxation, even though the spinous process A is to the left of our imaginary median line. The same is true of letter F, which represents center of the spinous process of the 4th dorsal; making same comparisons from F to G and F to H.

The fact that these spinous processes are nearer the right edges of the bodies, even though the spinous processes are to the left of the median line, shows there is a rotation of these bodies of the vertebrae, which in this case is a left rotation or a left rotatory scoliosis.

Next consider letters D and E, which represent the transverse processes of the 4th dorsal vertebrae. We find D is superior to E; adding this to our laterality which was found to be right, we then list the 4th dorsal as right and superior subluxations.

Letter I represents spinous process of the 5th dorsal showing it near the median line.

Letter J represents center of the spinous process of the 6th dorsal which you will notice overlaps the body of the 7th dorsal, due to the fact that the spinous processes in this region of the spine are very long.

You will also note spinous processes of the 4th, 5th, 7th and 8th dorsal overlap the body below. **Be very careful of this fact when reading plates of this region.**

Letter K represents spinous process of 7th dorsal.

Letters L and M outer edge of the body. On measuring between letters K and L and K and M we find the lesser distance between K and M, which proves it to be a left subluxation, although spinous process is to the right of the median line.

Letter N represents tip of spinous process of 7th dorsal, which is to the right of the center K which is the center of the spinous process. This indicates a bent spinous process to the right.

Letter O represents edge of the body of the 9th dorsal. Comparing this with letter L, which is the edge of the body of the 7th dorsal, we find it rotated farther to the right which gives a right rotation of the lower dorsal vertebrae.

If this was a left lateral scoliosis you would find the spinous process nearer the left edges of the bodies in. the upper dorsal.

In the lower dorsal, if you found the spinous processes nearer the right edge of the bodies, you would have a right lateral scoliosis.

Our spinographic listing would be as follows:

3rd dorsal R.
4th dorsal RS.
7th dorsal L. Spinous bent right with a left rotation from the 2nd to the 5th dorsal inclusive, and a right rotation from the 6th dorsal down.

RULES AND READING OF FIG. NO. 38

Rule No. 6—

Letter A represents spinous process of 1st dorsal.

Letters B and C are outer edges of the body.

First determine your laterality by comparing the center of the spinous process A with the ones above and below, measuring the distance between A and B and A and C. We find the distance is less between A and C, therefore a right subluxation.

To determine inferiority and superiority of this vertebra you must first take into consideration the right transverse process, which is superior to the left transverse process; next consider the angle of the superior and inferior border of the body from right to left, which still proves that the right transverse is superior. So we list it as a RS subluxation.

Figure No. 38 also shows a right rotatory scoliosis from the 8th dorsal down.

Letter D represents spinous process of the 3rd dorsal. and comparing with the one above and below, we find it to be left. On measurement, we find the distance is greater between D and E than D and F, making it a left subluxation even though it is curved to the right with a rotation. Also notice the tipping of this vertebra inferior on the left, making it an LI subluxation.

Letter G represents center of spinous process of the 5th dorsal; H and I outer edges of body, measurement proves it to be nearer the left edge of the body but not a left subluxation as its center is not to the left of the one

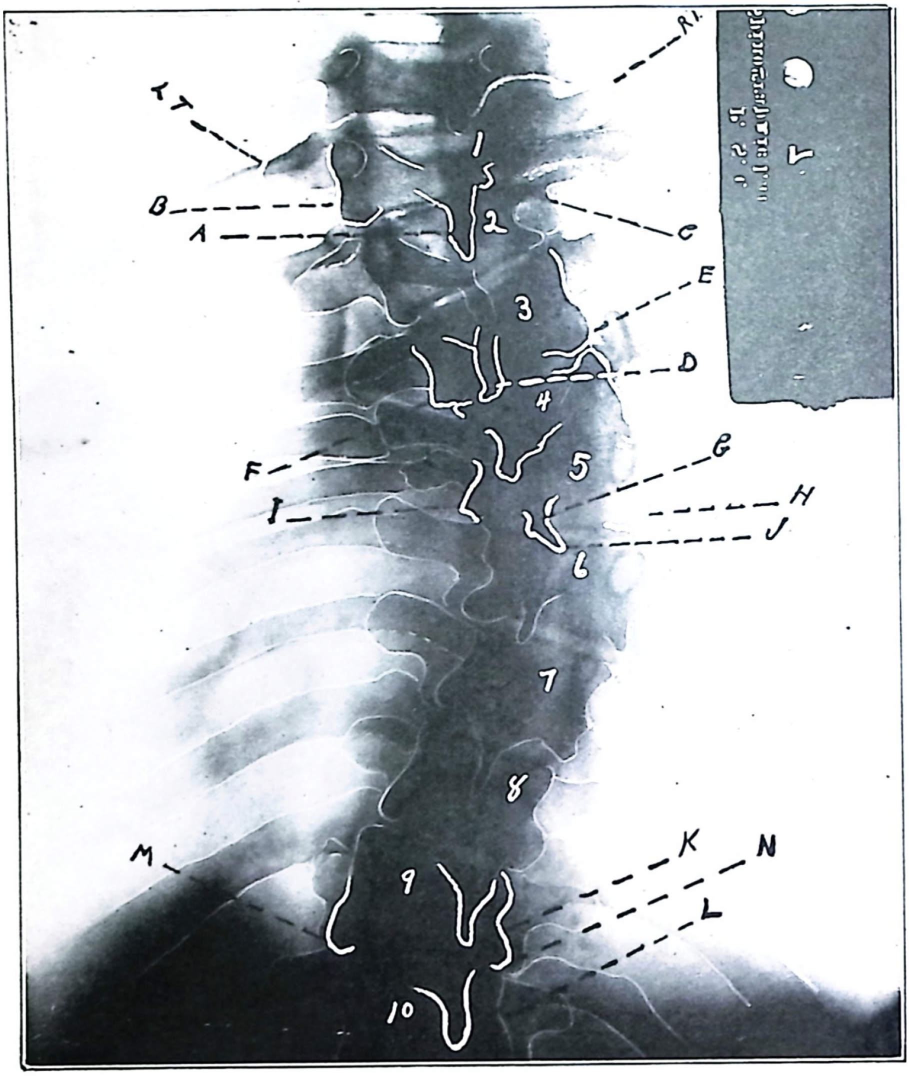


Figure 38

above and below it but is the apex of this rotatory scoliosis. You will also notice that letter J is the tip of the spinous process which is bent to the right of its own center which, under palpation would be listed as right.

Letter K, spinous process of the 8th dorsal, showing how it overlaps body of 9th dorsal.

Letter L spinous process of 9th dorsal.

Letters M and N outer edges of body. On measurement from L to M and L to N we find spinous process nearer N than M, showing that it is nearer the right edge of the body, but left of the spinous process of the 5th dorsal, showing how easily one would be misled when palpating a case of this kind. Notice tipping of this body inferior on right side, this tipping is adaptative to rotatory scoliosis. The curve is left in this region, therefore, a left rotatory scoliosis.

Our spinographic listing would be as follows:

1st dorsal RS.

3rd dorsal LI.

5th dorsal apex, with a bent spinous to the right.

9th dorsal apex, with a right rotation from the 3rd dorsal to the 6th dorsal inclusive, with a left rotation from the 8th dorsal down.

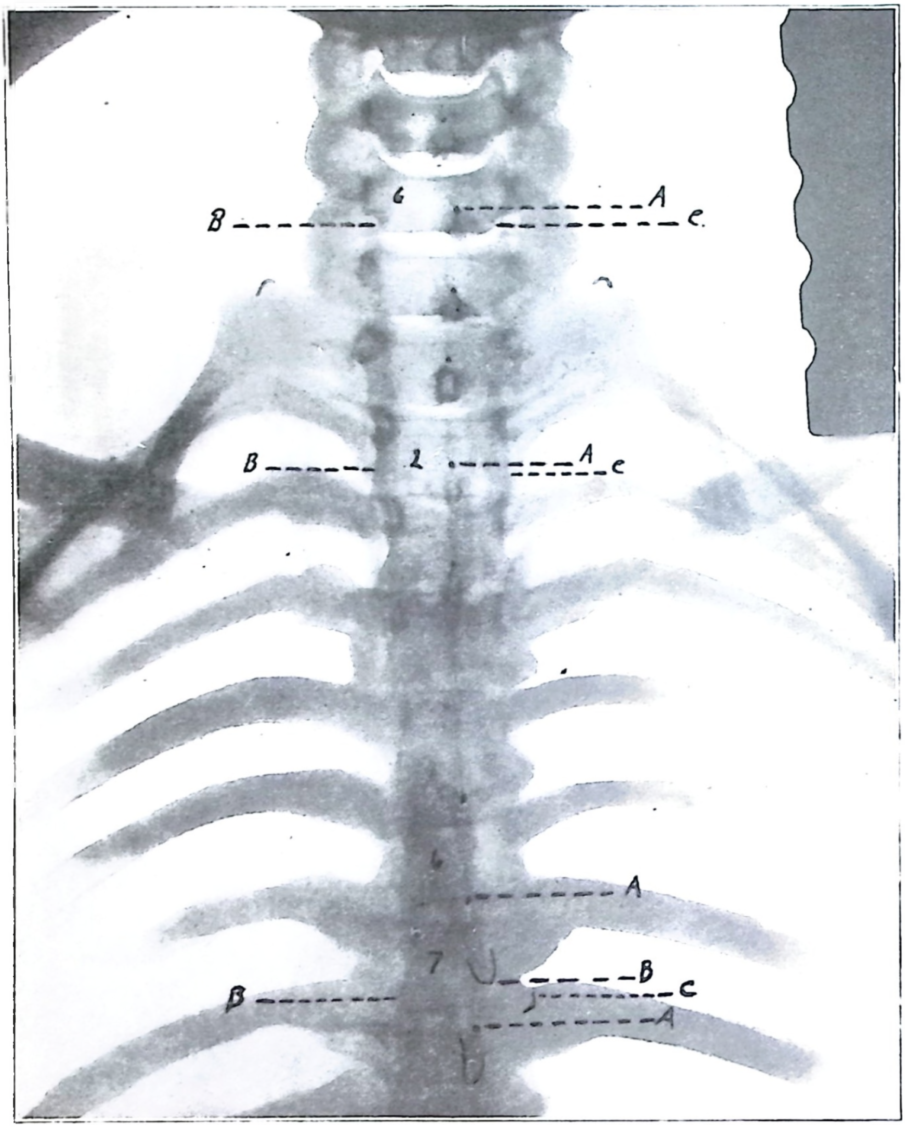


Figure 39

FOR READING FIG. NO. 39

We refer to Rule No. 3 to locate the first dorsal vertebra and to Rule No. 4 to determine the laterality in this region.

Letters D and D indicate the right and left transverse processes of the first dorsal vertebra.

Letter A represents the center of the spinous process of the sixth cervical. Letter C indicates the right edge of body of sixth cervical and letter B indicates the left edge of body of this vertebra. Now, by measuring from A to C and from A to B, we find the distance from A to C much shorter than from A to B.

Comparing the center of the spinous process of the sixth cervical with the center of the spinous process of the 5th and 7th cervical vertebrae, we find the sixth cervical very much to the right of the fifth and seventh, as well as being right of the center of its own body.

We now consider the 2nd dorsal vertebra. A represents the center of the spinous of this vertebra and B and C the right and left edges of the body of this vertebra. Measuring from A to B, and from A to C, we find that A is nearer to C and farther from B. We also compare this vertebra with the one above and below, and we find that it is also to the right of the adjacent vertebra.

A represents the center of ossification of the spinous process of the 6th dorsal vertebra. B represents the tip of spinous process of this vertebra. We find that B is very much to the right of the center A. This being due to the spinous process being bent badly to right.

A represents the center of the spinous process of the 7th dorsal, and B and C indicate the right and left edges of the body of this vertebra.

By measuring from A to C and from A to B we find we have a right subluxation of this vertebra.

Our listing of this plate would be:

6th cervical subluxated right.

2nd dorsal subluxated right.

6th dorsal spinous process bent right .

7th dorsal subluxated right.

FOR READING FIG. NO. 40

We turn back to Rules No. 3 and 4.

By application of Rule No. 3 we are able to locate the 1st dorsal.

Letter A represents an ankylosis of the 6th and 7th cervical vertebrae. Notice that the spinous processes of these two vertebrae are very close together and that the space between the spinouses of these vertebrae and the vertebra above and below is quite large. You will also note that the inter-vertebral disc between the 6th and 7th cervical does not show, due to the ankylosis which has formed.

A indicates the center of the spinous process of the 1st dorsal vertebra and B and C indicate the right and left edges of the body of this vertebra. Now we measure from A to B and from A to C and we find A much nearer to B than to C. Comparing the center of the spinous process of the 1st dorsal with the center of the spinous process of the vertebra above and below we find it very much to the right.

We now measure the 2nd dorsal. A represents the center of the spinous process of this vertebra and B and C indicate the right and left edges of the body of the same vertebra. Again we measure from A to B and from A to C and find A much nearer to B and farther from C.

We now compare the center of the spinous process of this vertebra with our imaginary median line and we find the 2nd dorsal to the right of this line as well as being right of the center of its own body.

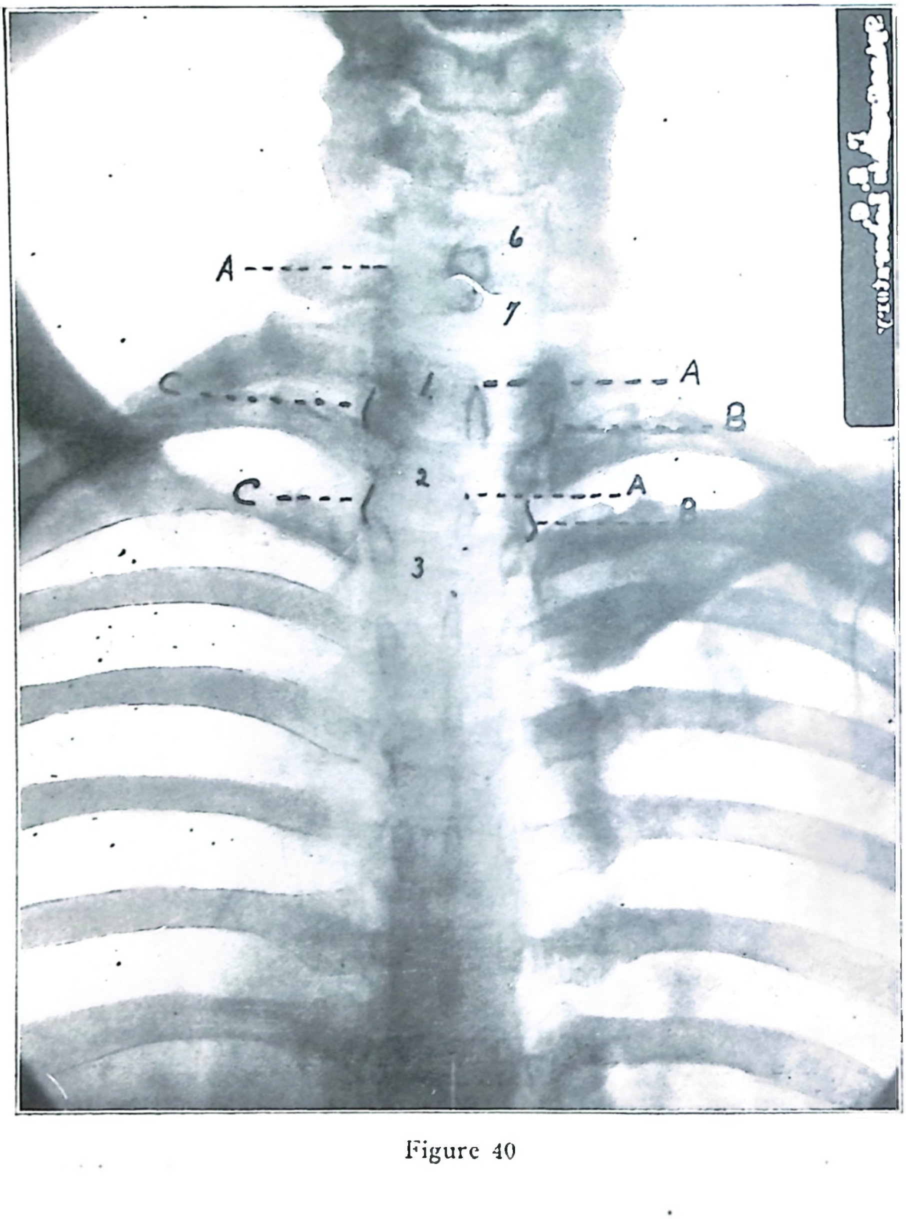


Figure 40

Our spinographic listing of this plate would be:

6th and 7th cervical ankylosed.
1st dorsal subluxated right.
2nd dorsal subluxated right.

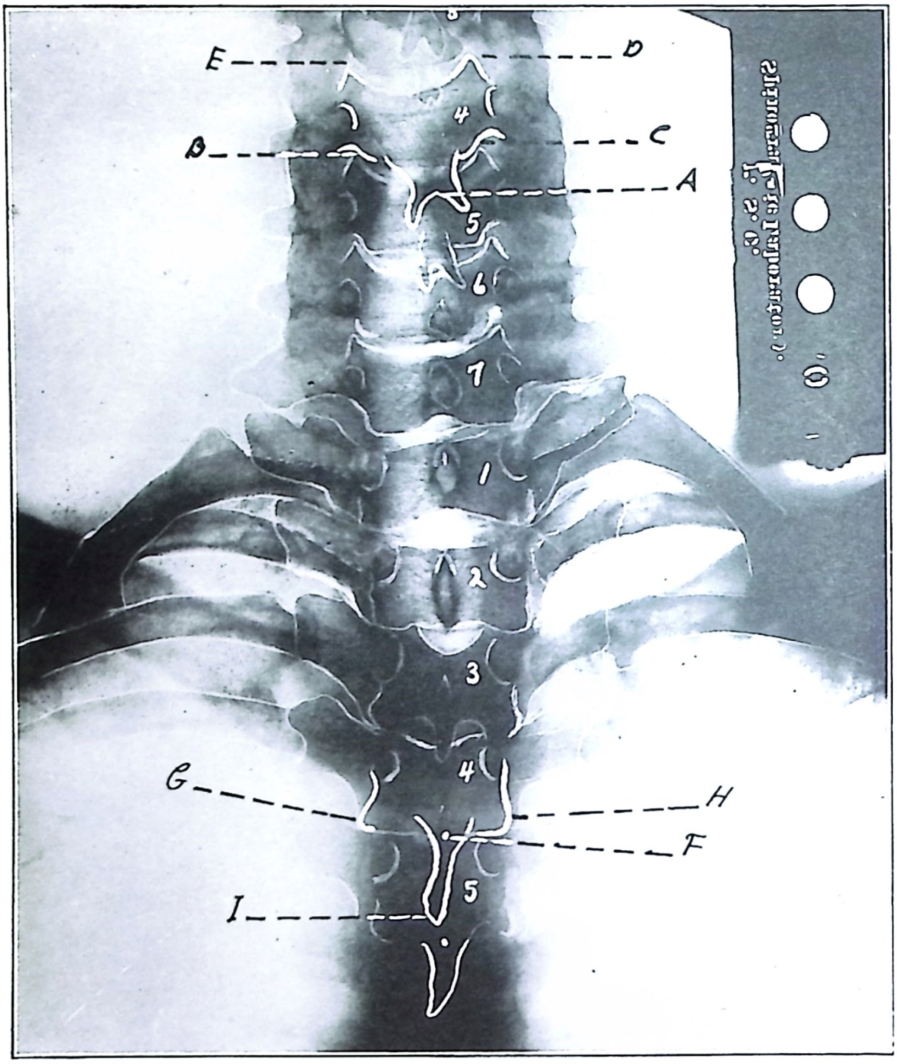


Figure 41

RULES AND READING OF FIG. NO. 41

Rule No. 7—

Letter A represents the center of the spinous process, of the 4th cervical vertebra, which in this case we find is the center of bifurcation so that we may use this center for comparison with the one above and below; B and C the outer edge of the body.

On measuring the distance from A to B and A to C we find that A is nearer to C and farther away from B, proving that the laterality is to the right.

Letters D and E represent the superior outer edge of the body of the 4th cervical vertebra. You will find that D is higher than E, also that C is higher than B, showing that the right side of this vertebra is superior to the left side of the vertebra, making it a right superior subluxation.

Letter F represents the center of the spinous process of the 4th dorsal vertebra which is the highest point of the center of the laminae where they meet to form the spinous process.

Letters G and H represent the outer edges of the body of the vertebra, comparing F with the spinous process above and below, we find it to be right; upon measurement we find that F is nearer to H and farther away from G, proving that we have a right subluxation of the 4th dorsal vertebra.

Letter I represents the tip of the spinous process of the 4th dorsal vertebra, which is found to be to the left of its own center F, showing that we have a bent spinous

process to the left; you will also notice how this spinous process overlaps the body of the 5th dorsal vertebra. It is in this region that the spinous processes are longer and that we will begin to find this overlapping.

Our spinographic listing would be as follows:

4th cervical RS, with a long left prong.
5th cervical long right prong.
4th dorsal right, with a bent spinous process to the left.

RULES AND READING FOR FIG. NO. 42

Fig. No. 42 represents a spinograph of the lower cervical and upper dorsal vertebrae. The same rule applies for reading as Fig. No. 13.

Letter A represents the center of the spinous process of the 4th cervical vertebra; B and C the outer edge of the body of the vertebra.

Upon measurement we find that letter A is much nearer C and farther away from B, showing that the laterality of this spinous process is to the right. Comparing the center of this bifurcation, it is found to be very much to the right of the one above it; also the spinous processes of the 5th, 6th and 7th cervical vertebrae are very much to the right. also producing a slight right scoliosis in this region. The right prongs of the 4th, 5th and 6th cervical are found to be much larger and longer than the left prongs and should always be listed in making the spinographic listing.

Letter D represents the spinous process of the 2nd dorsal vertebra; E and F the outer edge of the body of

the vertebra. Comparing D with the one above and below, we find it to the right. Upon measurement we find that D is nearer F and farther away from E, proving that we have a right subluxation. This spinous process is also bent to the right.

It is also found that the left transverse process marked LT is much higher than the right transverse process marked RT while the body of the vertebra itself appears to be level, showing then that the left transverse process is bent superiorly.

Letter G represents center of the spinous process of the 3rd dorsal vertebra; H and I the outer edges of the body of the 3rd dorsal vertebra.

Upon measurement we find that G is nearer I and farther away from H, showing that our laterality is to the right; also notice that the tip of this spinous process is bent to the left and upon palpation would palpate to the left of the tip of the spinous process above and below it, when in reality it is to the right of the median line of the vertebra itself.

Our spinographic listing would be as follows:

4th cervical R, with a long right prong.

5th cervical long right prong.

6th cervical long right prong.

Slight right scoliosis in this region.

2nd dorsal R, spinous process also bent right.

3rd dorsal R, with spinous process bent left.

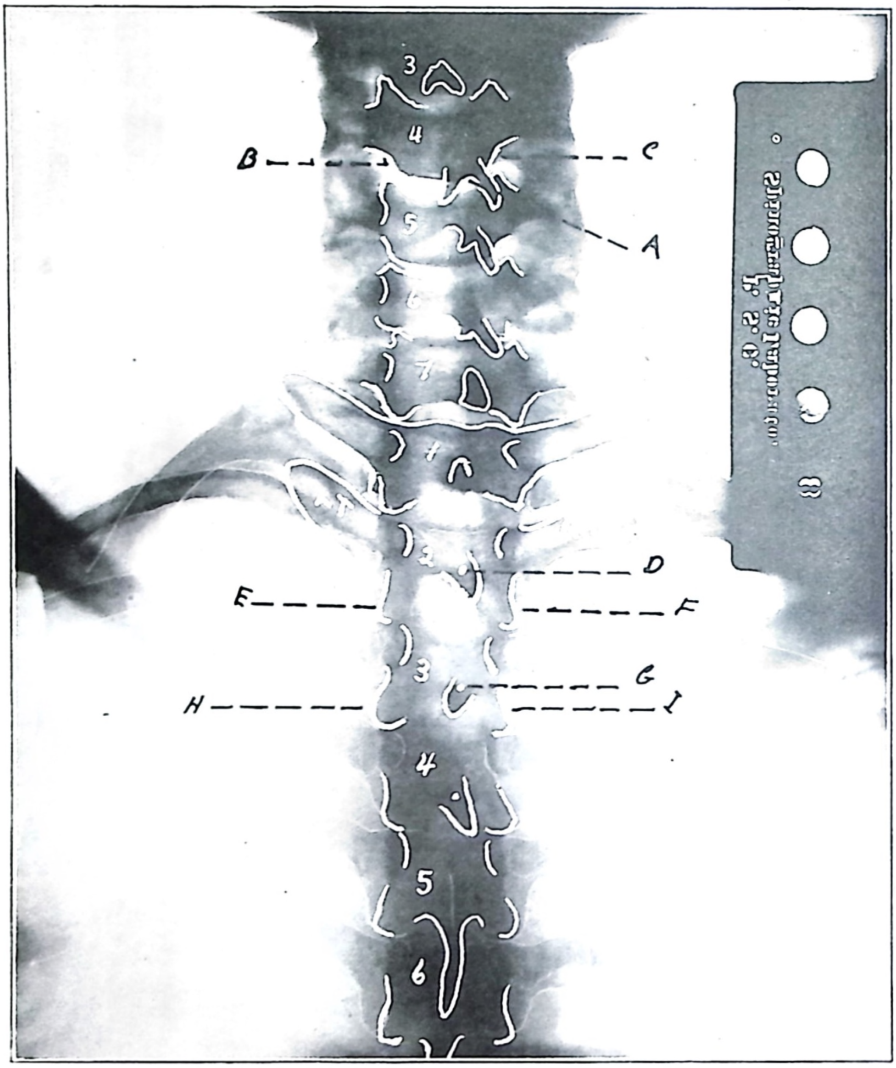


Figure 42

Fig. No. 43 shows a congenital deformity of dorsal region of the spine in which the bodies are malformed.

Upon counting the ribs we find that we have twelve on either side, but they are not in pairs as in the normal spine.

A represents the left transverse process of the 1st dorsal vertebra and B indicates the 1st rib and its articulation with the 1st dorsal on the left side.

Now, upon examining the right side of the 1st dorsal we find that there is no rib articulating with it on this side.

The 2nd, 3rd and 4th dorsal also have a rib articulating with each of them on the left side, but none on the right side.

By examining the 5th dorsal we find the 5th rib on the left side articulates with it and on the right side the 1st and 2nd ribs articulate with this vertebra.

We find the 6th rib on the left side articulating with the 6th dorsal while on the right side the 3rd and 4th ribs articulate with this vertebra.

C indicates a small wedge-shaped piece of ossious tissue between the bodies of the 6th and 7th dorsal vertebrae.

The 7th dorsal has the 7th rib on the left side and the 5th rib on the right side articulating with it.

D represents a wedge-shaped piece of a vertebra with which the 6th rib articulates on the right side.

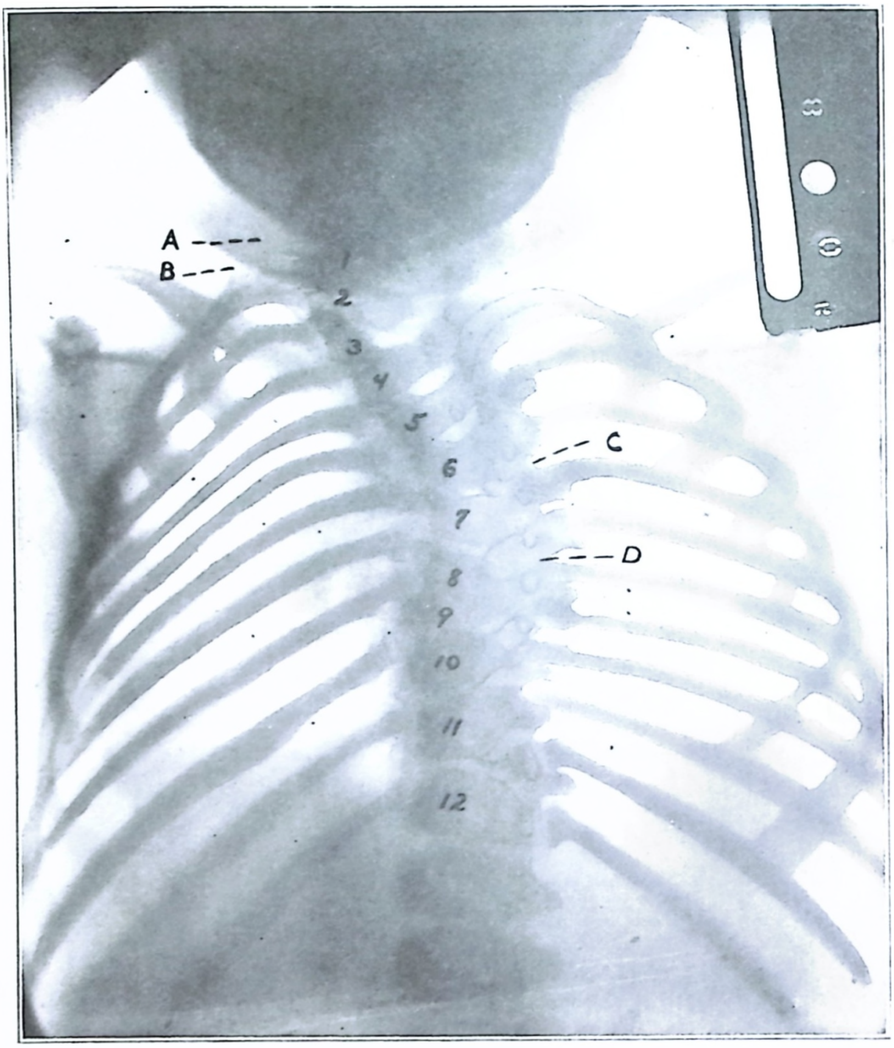


Figure 43

The 8th, 9th, 10th and 11th dorsal articulate with their corresponding ribs on the left, while on the right side they articulate with the 7th, 8th, 9th and 10th ribs, respectively.

The 11th rib on the right side articulates with a small piece of vertebra which is between the bodies of the 11th and 12th dorsal vertebræ. The 12th dorsal articulates with the 12th rib on either side.

It would not be advisable to adjust a case like this, neither would we be justified in attempting to make a spinographic listing of subluxations in a plate like this because of the irregularity in the shape of the bodies of the vertebra and in part of this region the spinous processes are not visible.

Here is just another instance showing the great value of spinography to the Chiropractor.

RULES AND READING FOR FIG. NO. 44

In determining laterality of the vertebrae in Fig. No. 44 we refer back to Rule No. 4.

Letter A represents spinous process of the 11th dorsal. B and C outer edges of body. On measurement we find that we have a left subluxation, while the tip of the spinous process D is bent slightly to the right and upon palpation with a comparison of the spinous processes of the 10th and 12th dorsal vertebrae, it would be listed as a right subluxation, while in reality it is left.

Letter F represents spinous process of 9th dorsal.

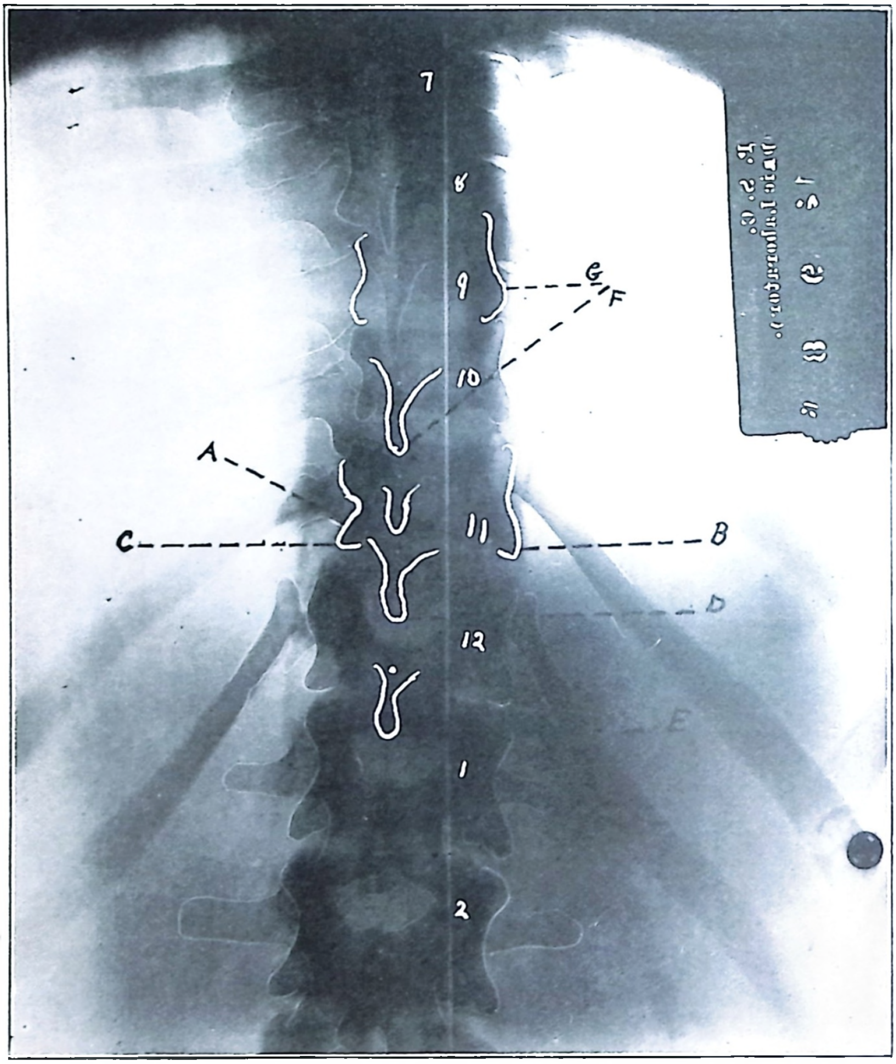


Figure 44

Letter G the body of the 9th dorsal, showing the length of this spinous process and how it overlaps the body of the 10th dorsal and upper part of the 11th. This condition is found in the majority of all lower dorsal plates and one must be very careful when comparing these spinous processes with the one above and below and measuring the distance from the center of the spinous process to the edge of its own body. Bear this point in mind, as one is apt to mistake that spinous process as belonging to the body that it overshadows.

There is a scoliosis to the right, while the spinous processes are nearer the left edges of the bodies, showing that it is a right rotatory scoliosis.

Our spinographic listing would be as follows:

11th dorsal L, with a bent spinous process to the right, with a right rotation extending from the 7th dorsal to the 2nd lumbar inclusive, 11th dorsal being the apex of this right rotation.

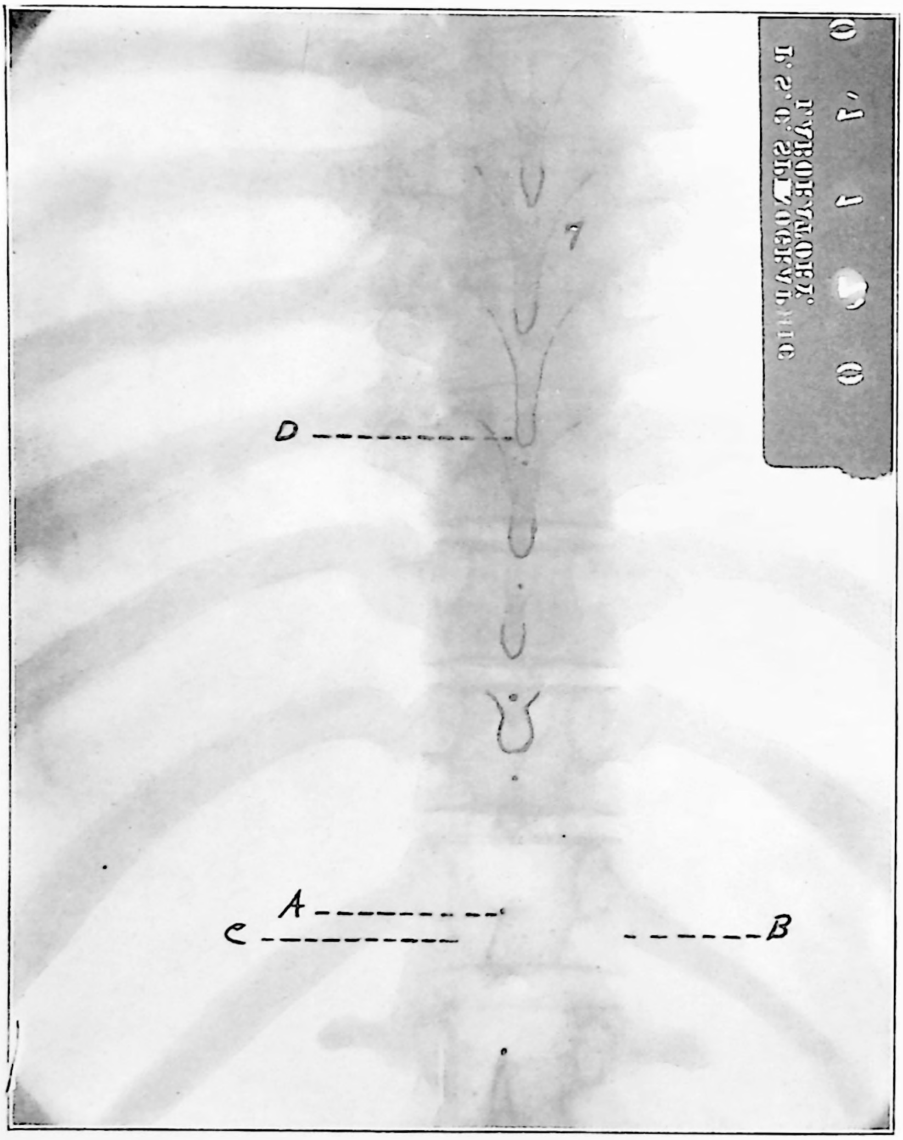


Figure 45

IN READING FIG. NO. 45

Rule No. 4 applies.

This plate shows the lower dorsal, and the first thing we must do is to locate the 12th dorsal, which is done by finding the last pair of ribs as they are attached to the 12th dorsal vertebra. Sometimes these ribs are very short and sometimes only one rib is found attached to the 12th dorsal. The 12th dorsal is also a transitional vertebra and the inferior articulating processes present the characteristics of the lumbar vertebra.

Letter A represents the center of the spinous process of the 12th dorsal and B and C represent the right and left edges of the body of this vertebra. Now we measure from A to B and from A to C and we find the distance from A to C is shorter than from A to B. This measurement shows the center of the spinous process A to the left of the center of the body of the vertebra in question. Now, by comparing the center of the process of the 12th dorsal with the spinous processes of the 11th dorsal and the 1st lumbar, we find the 12th dorsal to the left of them as well as left of its own body.

Letter D represents the tip of the spinous process of the 7th dorsal. Notice the length of the spinous processes in this region; for example, the process of the 7th dorsal extends down over the body of the 8th and the superior border of the 9th dorsal vertebrae.

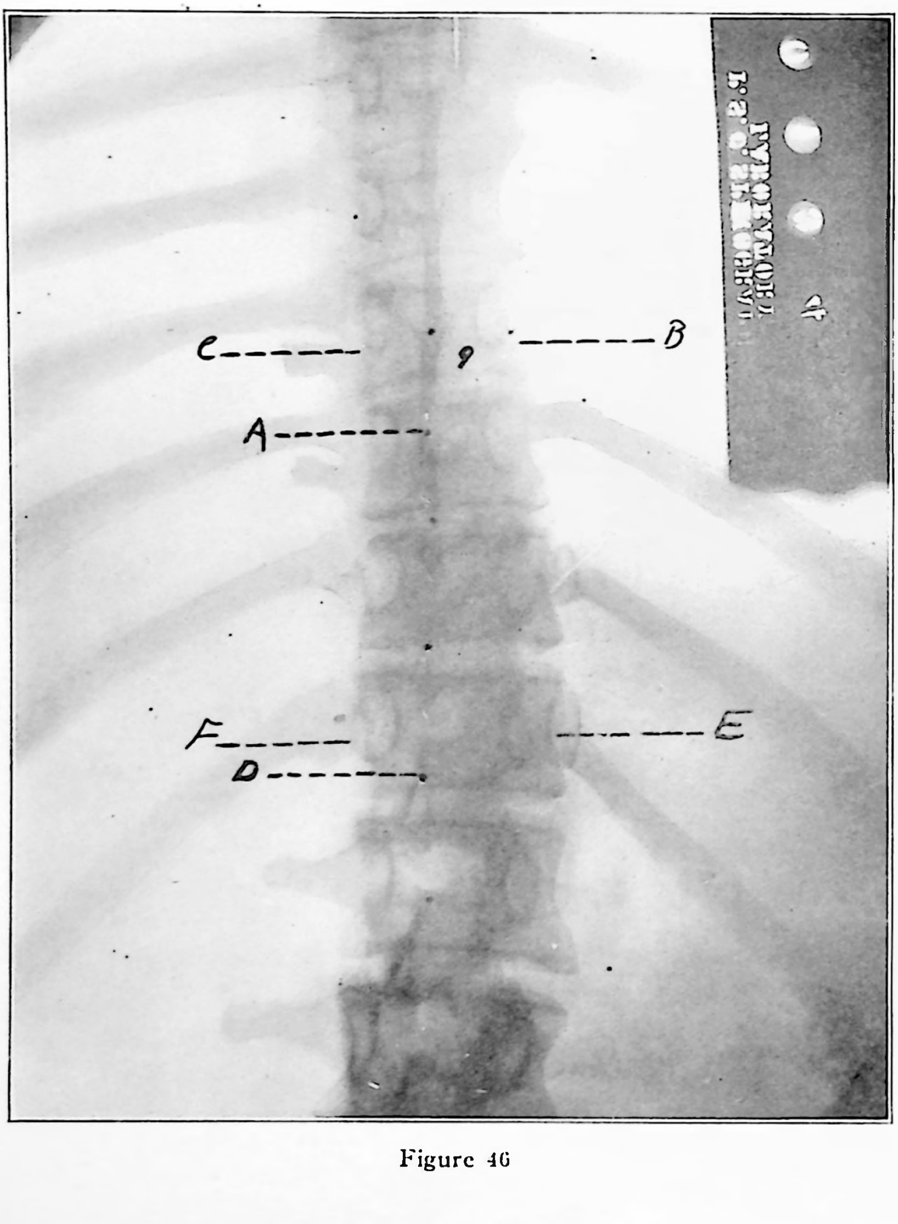


Figure 46

FOR READING FIG. NO. 46

We refer back to Rule No. 4 to determine laterality and to rule No. 5 to determine the rotation.

We measure from the center of the spinous processes to the edges of the bodies and we find the spinous processes nearer to the left edges of the bodies from the 9th dorsal to the 2nd lumbar, inclusive; there is also a light curve to the right and we would list this as a right rotation.

A represents the center of ossification of the spinous process of the 9th dorsal vertebra and letters B and C indicate the right and left edges of the body of this vertebra. Now we measure from A to B and from A to C and we find that the center of the spinous process A is closer to C and farther from B. This proves to us that the center A is to the left of the center of the body of the vertebra itself. Now we compare A with the center of the spinous processes of the vertebra above and below and we find the 9th dorsal left of them as well as being left of its own body.

Now we will consider the 12th dorsal vertebra. D represents the center of the spinous process and E and F indicate the right and left edges of the body of the 12th dorsal. Upon measuring the distance from D to E and from D to F we find D nearer to F and farther from E, which fact proves to us that the center D is to the left of the center of its own body.

Now compare D with the center of the spinous of the 11th dorsal and of the 1st lumbar, and we find the 12th dorsal to be to the left of the vertebra above and below as well as left of its own center.

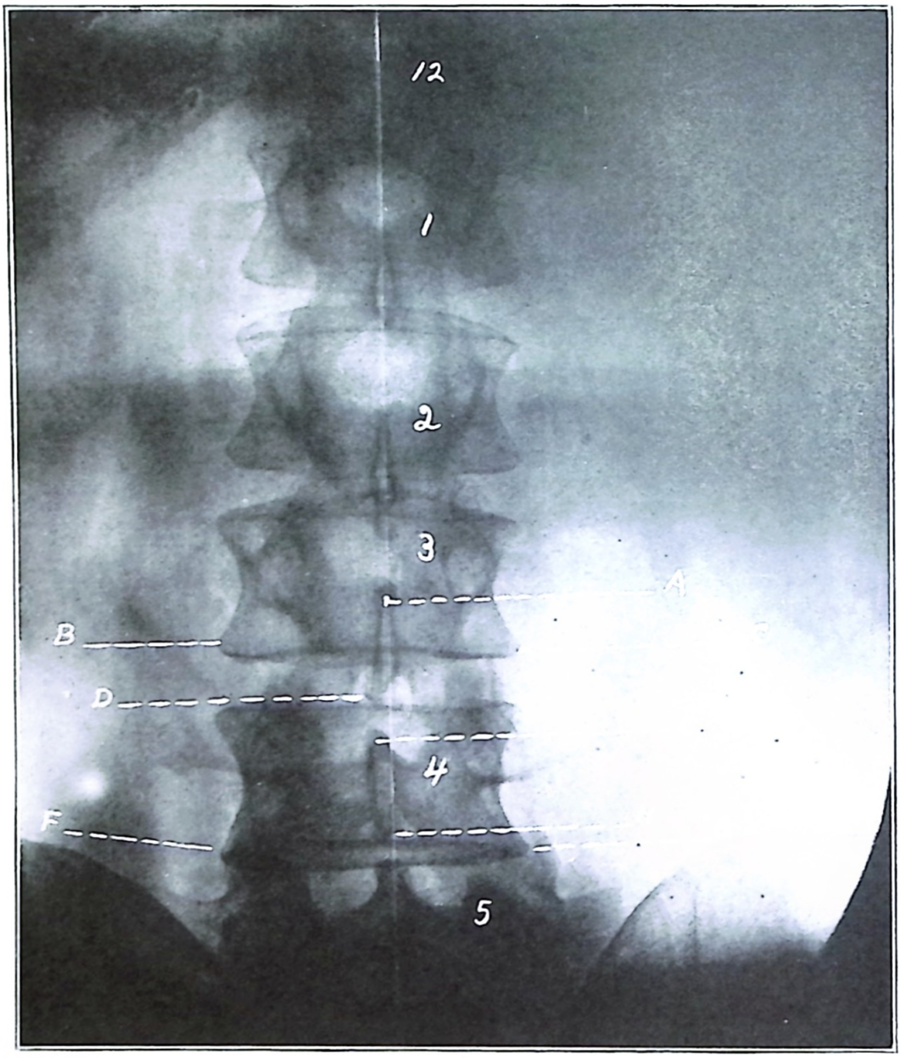


Figure 47

Our spinographic listing of this plate would be:

9th dorsal subluxated left.

12th dorsal subluxated left and right rotation from the 9th dorsal to the 2nd lumbar, inclusive.

RULES AND READING FOR FIG. 47

The laterality in this figure is determined in using Rule No. 4.

You will notice upon close examination that there is very little laterality of the vertebrae by comparing one spinous process with another as far as the eye can detect, but upon measurement we find there is laterality to the 3rd and 4th lumbar vertebræ.

Letter A represents center of the spinous process of the 3rd lumbar vertebra.

Letters B and C the outer edges of the body of the vertebrae.

Upon measurement we find that A is nearer to C and farther away from B, showing that the spinous process is to the right of the median line of the vertebra itself.

Letter D represents the tip of the spinous process of the 3rd lumbar vertebra which, upon careful examination, is found to be to the left of its center A, proving that we have a right subluxation with a bent spinous process to the left. In considering the 4th lumbar vertebra notice that the center of the spinous process E is to the left of the letter A, but still upon measurement from E to F and E to G, we find that E is nearer G than F, proving that it is a right subluxation, even though the

center of the spinous process E is to the left of the center of the spinous process A. This vertebra could be adjusted from the left in a very acute condition, as it is to the left of the spinous process above and below it and bears out the fact that we can have a left subluxation in a left rotation, even though adjusted from the left and increase the rotation. The adjustment would bring the spinous process into alignment with the one above and below, relieving the impingement temporarily. This is a condition that should never be listed unless the Chiropractor is handling the case himself and it is for that reason that it is listed as a right subluxation rather than left, so that any one adjusting from this analysis would not adjust the 4th lumbar from the left for a great length of time, as he would eventually produce a greater rotation and possibly more acute symptoms, so bear in mind that a left subluxation in a left rotation or a right subluxation in a right rotation is possible, but it is not good policy to make such listings.

Letter H represents the tip of the spinous processes of the 4th lumbar vertebra, showing that it is to the right of its own center E, indicating a bent spinous process to the right, even though our laterality is found to be to the right of its own body. Comparing the tip of the spinous process D, which is bent left with tip of spinous process H. it can be seen that upon palpation D would palpate to the left of H. One example of what bent spinous processes will do.

Our spinographic listings would be as follows:

3rd lumbar subluxated right, with a bent spinous process to the left.

4th lumbar a spinous process to the right of its own body but left of the spinous processes above and below it, with a bent spinous process also to the right.

RULES ON READING OF FIG. No. 48

We determine laterality in the lumbar region the same as in Rule No. 4 by comparing the centers of the spinous processes with the ones above and below and the comparative measurements from the center of the spinous processes to the edges of the bodies to prove our first findings.

Almost all lumbar plates take in the 12th dorsal which shows the last pair of ribs and it is this fact that enables one to determine the correct count of the lumbar vertebrae.

Letter A represents the center of the spinous process of the 12th dorsal.

Letters B and C outer edges of the body.

In comparing the center of the spinous process A with the one above and below, it is found to be left. Measuring the distance from A to B and A to C we prove it to be a left subluxation. With the tip of the spinous process D bent to the right of its own center A, spinographic listing would be a left subluxation with bent spinous processes to the right.

Letter E represents the center of the spinous process of the 3rd lumbar.

Letters F and G outer edges of the body. Comparing center of spinous process, also with one above and below,

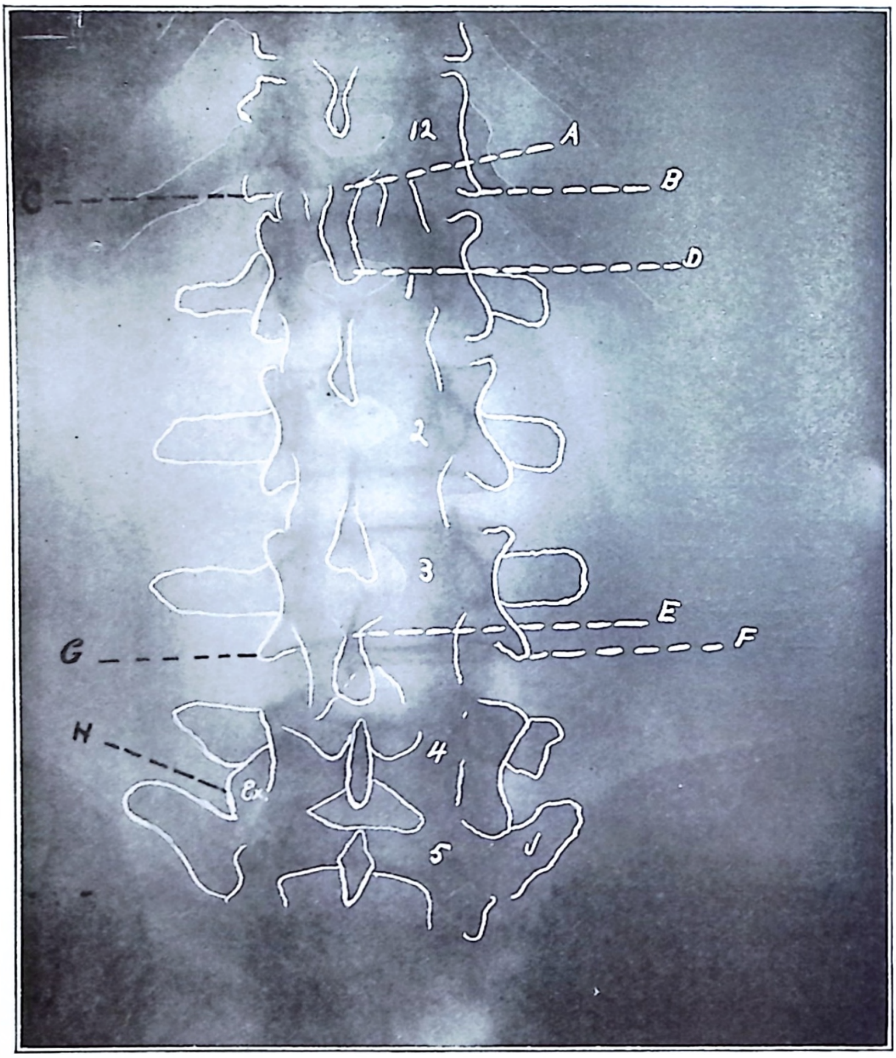


Figure 48

it is found to be left, measuring the distance it is proven to be a left subluxation. Also considering the inferiority and superiority, we find the left side to be superior, so we add this to our laterality, which would be listed as follows: 3rd lumbar L and slightly superior.

Letter H shows an exostotic growth between the bodies of the 4th and 5th lumbar vertebrae. There is also a slight right rotatory scoliosis in this region.

Our spinographic listing would be as follows:

12th dorsal L, with a bent spinous process to the right.

3rd lumbar LS with an exostosis and ankylosis between the 4th and 5th lumbar vertebrae, with a right rotation extending from the 12th dorsal to the 5th lumbar, inclusive.

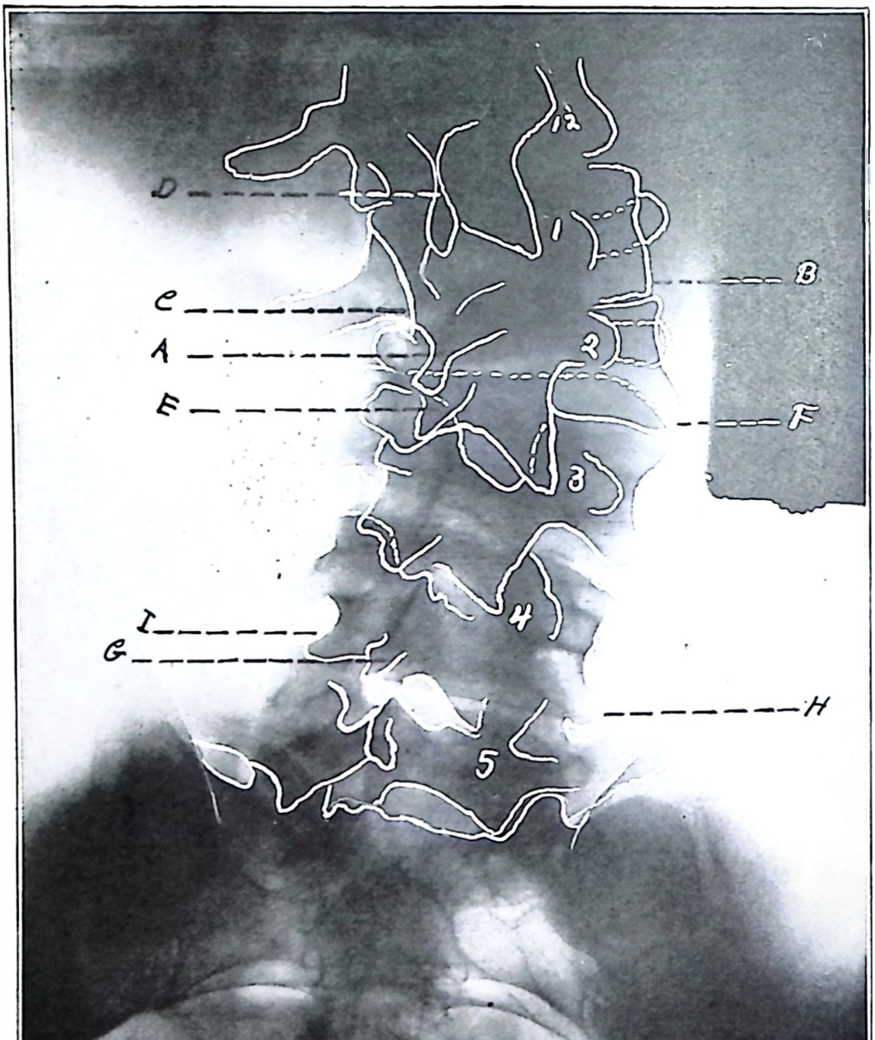


Figure 49

RULES AND READINGS FOR FIG. NO. 49

Figure No. 49 presents a condition which refers us back to Rule No. 5, in how to determine a rotatory scoliosis. It can easily be seen that we have a curvature to the right, and we must determine whether or not we have a rotatory scoliosis or a lateral scoliosis.

First we will take letter A, which is the center of the spinous process of first lumbar vertebra, comparing A with the center of the one above and below, we find it left; then measuring the distance from B to C, which is the outer edge of the body of this vertebra, we find that A is nearer to C and farther away from B, proving that this spinous process is to the left of the median line of the vertebra itself; therefore, our laterality must be left. Notice there is a tipping to the inferior upon the left side, which is more adaptative to the scoliosis than being an inferior subluxation. It is also found that in a rotatory scoliosis that there is a tipping inferiorly in the upper part of a rotation while they are tilted to the superior in the lower part of a rotation. This fact must be carefully noted when attempting to list the superiority or inferiority in a rotatory scoliosis.

Letter D represents the spinous process of the 12th dorsal vertebra, showing how it overlaps the body of the first lumbar vertebra.

Letter E represents the center of the spinous process of the 2nd lumbar vertebra.

Letter F the right edge of the body.

You will notice upon measurement that E is very far away from F and closer to the left edge of the body. You

will notice that the left edge of this body is not lettered, as the body itself is wedge-shaped with ankylosis between the 1st, 2nd and 3rd lumbar vertebrae; also we find that letter F is farther to the right than the body above or below it, proving that this is the apex of this rotatory scoliosis.

Letter G represents the center of the spinous process of the 4th lumbar vertebra.

Letters H and I the outer edges of the body of the vertebra. Measuring the distance from G to H and G to I we find that G is nearer I and farther away from H, proving that this spinous process is to the left of the median line of the vertebra itself; also that I is much higher or superior to H.

Therefore, our findings prove that the spinous processes are nearer the left edges of the bodies of the vertebrae in this region while the curvature is right, showing that we have a right rotation of the bodies of the vertebra with all the spinous processes being left; this condition would then be listed as a right rotatory scoliosis or right rotation.

Our spinographic readings would be as follows:

1st lumbar LI.

2nd lumbar L, with cord pressure.

4th lumbar LS, with a right rotation of the bodies of the vertebræ, 2nd lumbar as apex; with ankylosis between bodies of the 1st, 2nd and 3rd lumbar vertebrae.

It is in rotations of this degree that the Chiropractor must be more than careful when palpating in case that he does not mistake the transverse processes for the spinous processes, as they are naturally rotated to the posterior and in many cases are very prominent while the spinous processes are rotated left and to the anterior as the right side of the bodies are rotated to the posterior.

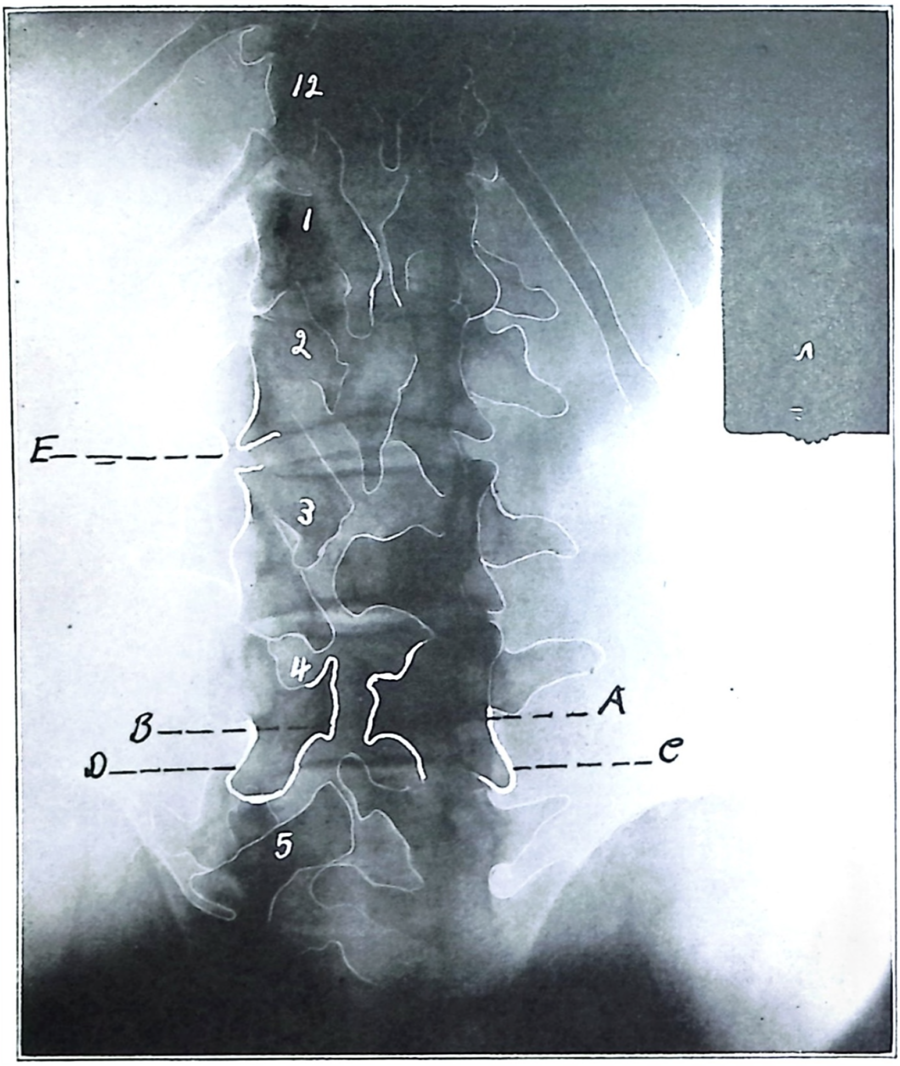


Figure 50

RULES AND READING FOR FIG. NO. 50

Rule No. 11.

Always be on the lookout for other abnormal conditions, as you may find exostoses, ankyloses, curvatures, fractures, caries or tubercular conditions, etc.

Figure No. 50 presents an abnormal condition of the 12th dorsal and all the lumbar vertebrae other than subluxations.

Letter A represents the right laminæ of the 4th lumbar vertebra, letter B representing the left laminæ of the 4th lumbar vertebra. We find that the laminæ have never united to form a spinous process.

Letters C and D represent the outer edges of the body of the 4th lumbar vertebra. Measuring the distance from the center of the space found between the laminae to C and D, we find that the center is nearer D and farther away from C, showing that we have a left subluxation of the 4th lumbar vertebra.

Letter E shows the outline of an exostosis and ankylosis along the left edges of the bodies of the 2nd and 3rd lumbar vertebrae.

You will find that none of the laminae in this lumbar region have united to form spinous processes, this condition is pre-natal and is termed a cleft spine. Where there is a protrusion of the spinal cord or membranes it is termed spinal-bifida.

Our spinographic listing would be as follows:

4th lumbar L.

Exostosis and ankylosis between the 2nd and 3rd lumbar vertebrae, with a cleft spine from the 12th dorsal to the 5th lumbar, inclusive.

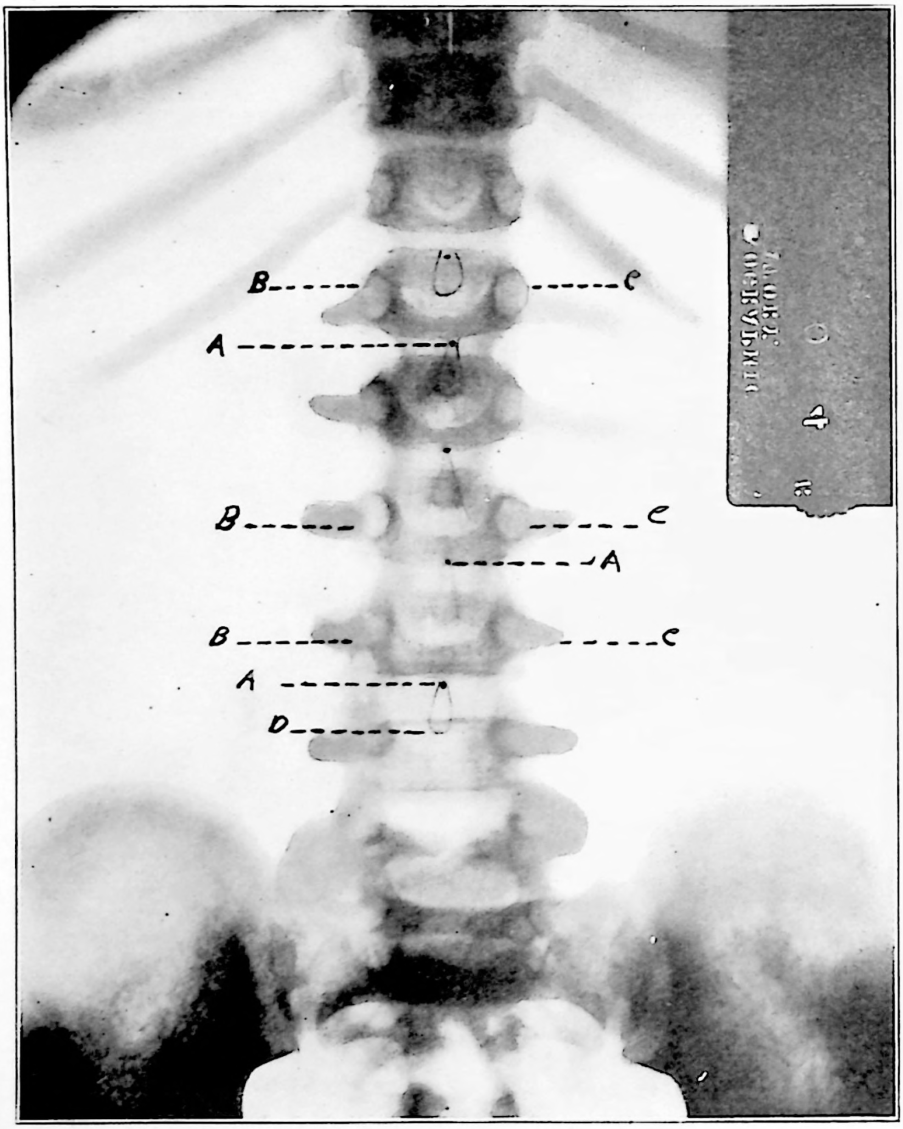


Figure 51

FOR READING FIG. No. 51

We refer to Rule No. 4.

Letter A represents the center of the spinous process of the 1st lumbar vertebra and B and C indicate the right and left edges of the body of the same vertebra. Now, to determine whether this vertebra is subluxated laterally, we measure from A to B and from A to C and we find the distance from A to C shorter than from A to B, so we find the 1st lumbar subluxated right, or, in other words, the center of the spinous process of the 1st lumbar is to the right of the center of its own body.

By comparing the center A with the center of the spinous processes of the 12th dorsal and 2nd lumbar we find that it is also to the right of them. A represents the center of the spinous process and B and C the right and left edges of the body of the 3rd lumbar vertebra. By measuring from A to B and from A to C we find that A is nearer to C and farther from B. We now compare the center of the spinous process of the 3rd lumbar with the center of the spinous processes of the vertebra above and below and we find the 3rd right of them as well as right of its own body.

A represents the center of the spinous process of the 4th lumbar. B and C indicate the right and left edges of the body of this vertebra. Now, by measuring from A to B and from A to C, we find the distance to be the same on both sides, so we decide that the 4th lumbar is not subluxated.

From palpation the tip of the spinous process D would palpate to the left; this is due to the spinous being bent left of the center A.

Our spinographic listing of this plate would be:

1st lumbar subluxated right.
3rd lumbar subluxated right.
4th lumbar spinous bent left.

FOR READING FIG. No. 52

Fig. No. 52 is an anterior-posterior view of a broken back, showing a disclocation and fracture of the 2nd lumbar vertebra.

A represents the center of the spinous of the 1st lumbar vertebra. B represents the center of the spinous process of the 2nd lumbar. C indicates the left superior articulating process of the 2nd lumbar which has been broken off the body of this vertebra.

Notice the offset of approximately one inch between the right edges of the bodies of the 1st and 2nd lumbar vertebrae on the right side; this condition would produce very great pressure upon the canda equina.

Immediately following this accident there was a total paralysis of all organs and structures supplied by nerves emitting below the 1st lumbar vertebra.

It is safe to say that a case of this type could not be adjusted due to the fracture of the body of the 2nd lumbar vertebra, which takes it out of the Chiropractic field.

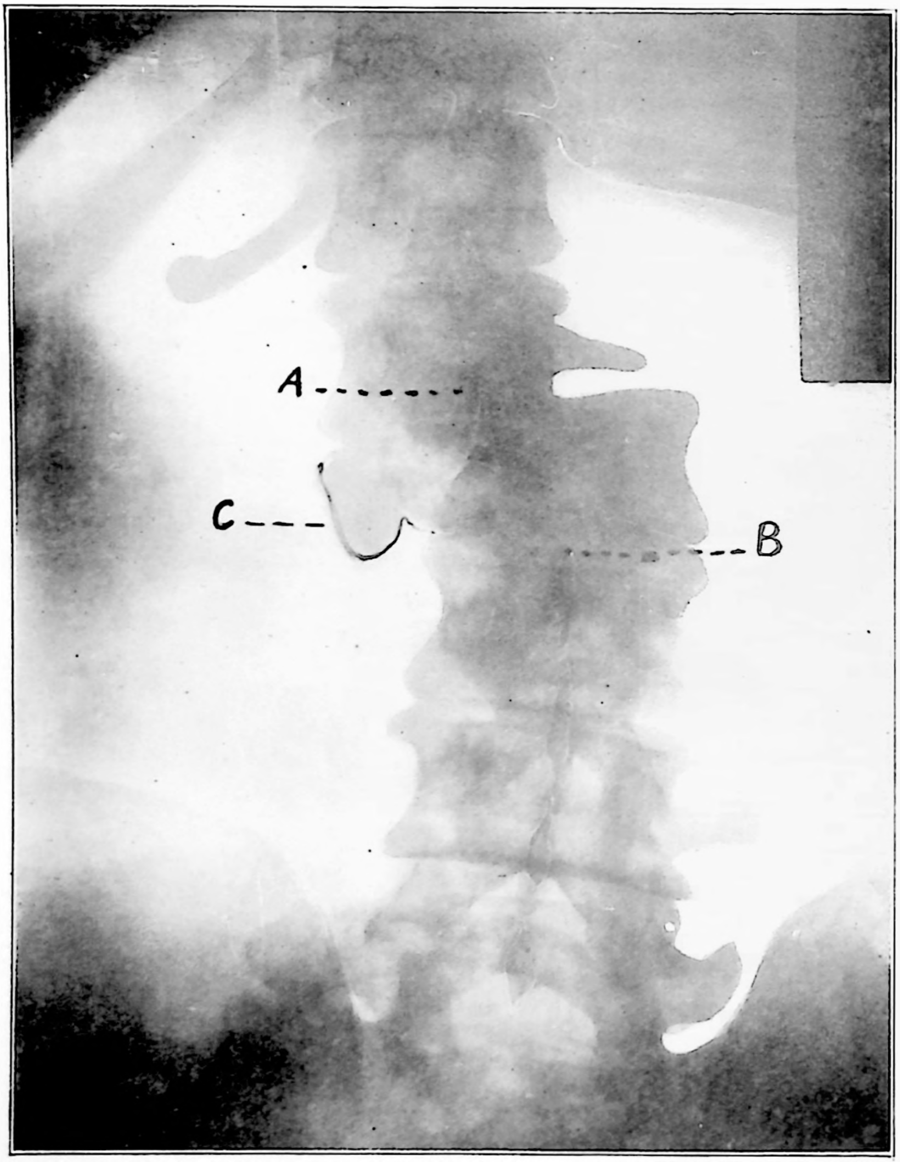


Figure 52

FOR READING FIG. NO. 53

We refer to Rule No. 5.

This plate shows a lower dorsal and lumbar region in which there is a right rotation of the 11th and 12th dorsal and the 1st lumbar vertebrae, and a left rotation of the 3rd and 4th lumbar, while the 2nd lumbar, which is between these two rotations, remains in its normal position.

AA indicates the center of the spinous process of the 2nd lumbar and BB and CC represent the right and left edges of the body of this vertebra. Now, by measuring from the center of the spinous process to the right and left edges of the body of the 2nd lumber, we find the distance to be the same on either side; this proves to us that this vertebra is in its normal position.

We will now consider the 3rd and 4th lumbar vertebrae. A represents the center of the spinous process of the 3rd lumbar and C and B indicate the right and left edges of the body of this vertebra. Upon measuring from A to B and from A to C we find that the distance from A to C is much shorter than from A to B, proving that this vertebrae is rotated to the left.

D indicates the center of ossification of the spinous process of the 4th lumbar vertebra and E and F indicate the right and left edges of the body of this vertebra.

Now, by comparing the distance from D to E and from D to F, we find D much nearer to E and farther from F; this fact proves to us that the 4th lumbar is also rotated to the left.

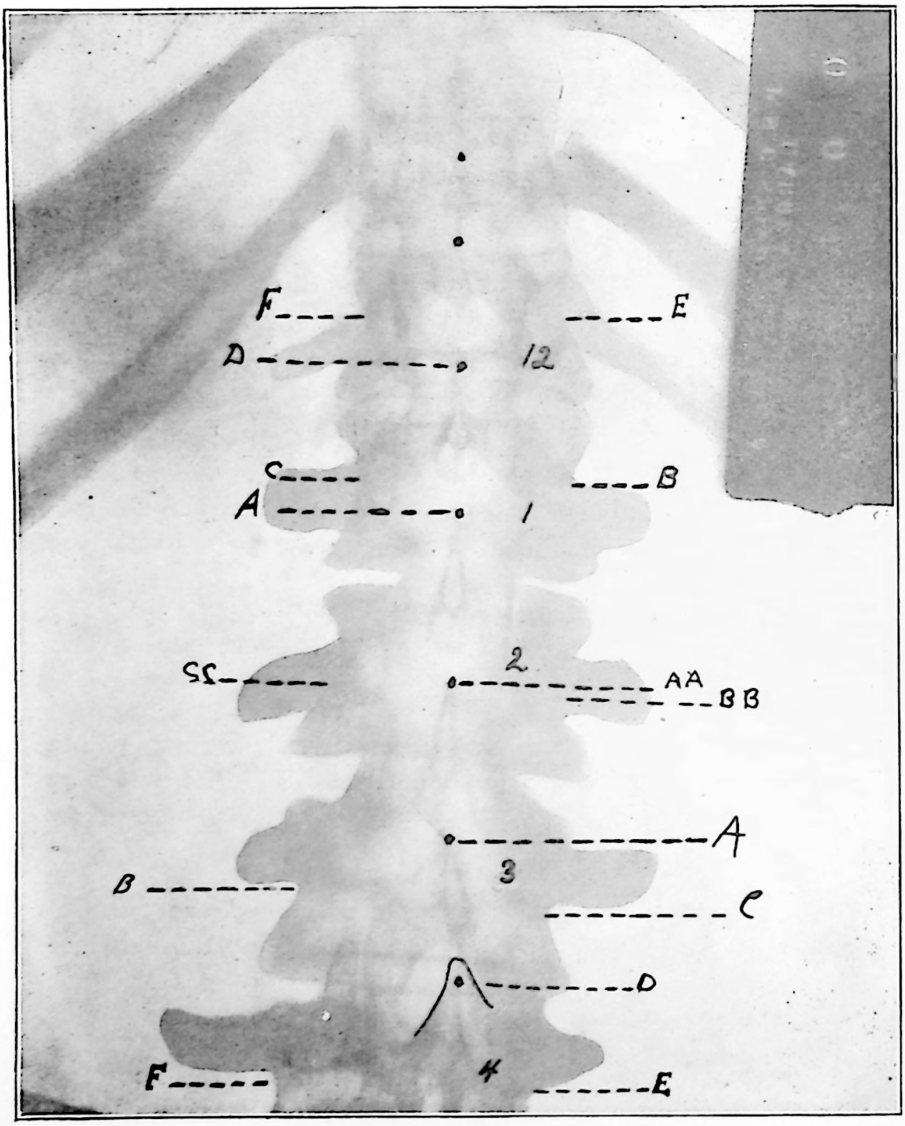


Figure 53

We now compare the center of the spinous process of the 4th lumbar with the 2nd and 3rd, and we find the center D to the right of A and AA, therefore we would list the 4th lumbar subluxated right.

We now consider the 1st lumbar and 12th dorsal.

A represents the center of the spinous process of the 1st lumbar. B and C represent the right and left edges of the body of this vertebrae. By measuring from A to B and from A to C we find A nearer to C and farther from B, giving us a right rotation of this vertebra.

We now measure the 12th dorsal, the center of the spinous process of which is represented by D, the right and left edges of the body are indicated by E and F, respectively. Measuring from D to E and from D to F we find D nearer to F and farther from E, so we find the 12th dorsal also rotated to the right.

The spinographic listing of this plate would be:

12th dorsal and 1st lumbar rotated right.

3rd and 4th lumbar rotated left.

4th lumbar subluxated right.

FOR READING FIG. No. 54

Fig. No. 54 shows a lumbar region in which the 3rd lumbar vertebra is partly destroyed. This condition is the result of Pott's disease.

A represents the left superior and inferior edges of the body of the 3rd lumbar vertebra. It will be noticed that the body of this vertebra is much thinner than the

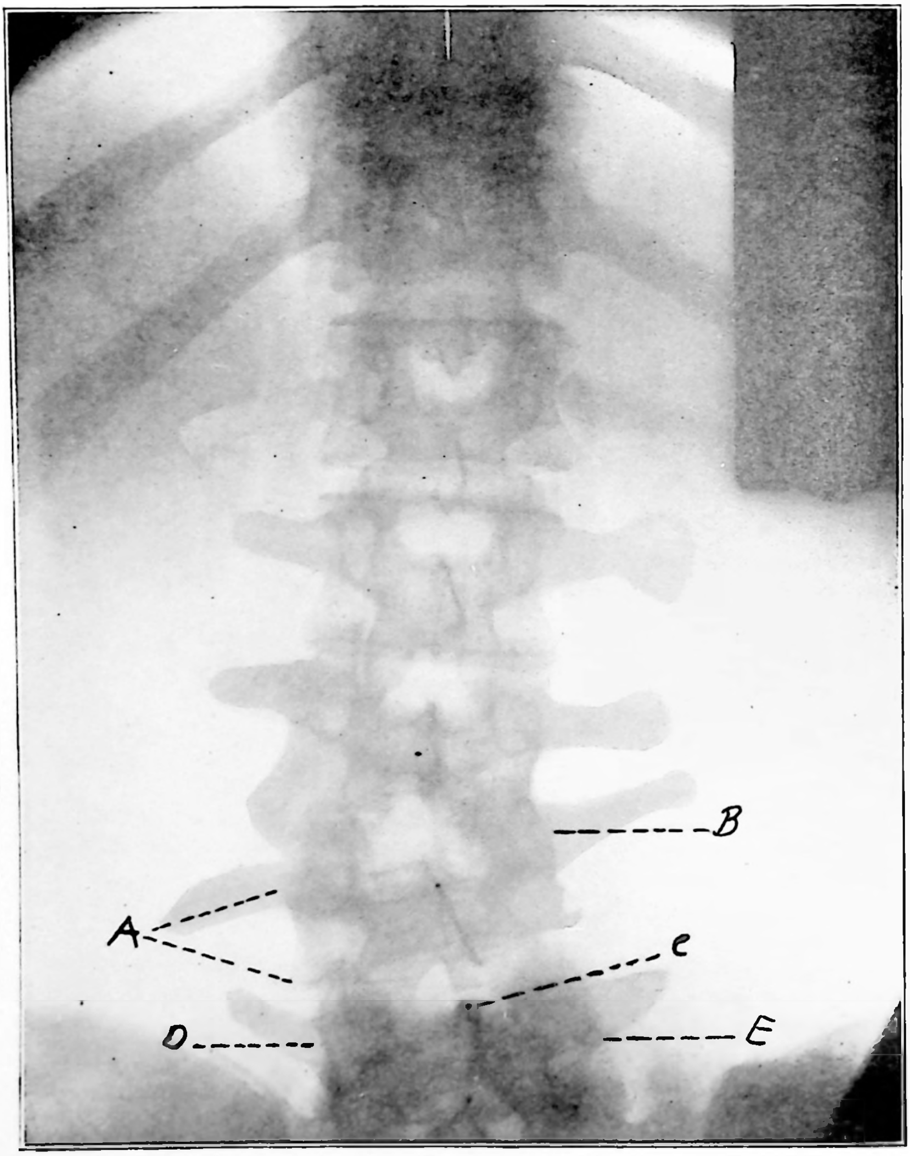


Figure 54

bodies of the other vertebræ in this region; notice also that the right edge of the body of this vertebra is thinner than left edge; because of this fact we have an extremely short curve to the left at this point.

B indicates an ankylosis of the remaining portion of the body of the 3rd lumbar vertebra to the inferior edge of the body of the 2nd lumbar on the right side. Also notice that the right transverse process of the 3rd lumbar is in direct contact with the inferior edge of the 2nd lumbar and is solidly ankylosed at B.

Letter C represents the center of ossification of the spinous process of the 4th lumbar. D indicates the left edge of this vertebra and E the right edge. We now compare the distance from C to D and from C to E according to Rule No. 4 and we find that C is farther from D and nearer to E, giving us a right subluxation of this vertebra. We now compare the center of the spinous of the 4th with the center of the 3rd and 5th lumbar and we find that the 4th is to the right of the 3rd and 5th as well as right of its own body.

It is not advisable to break an ankylosis of this nature. as it is adaptative and when the ankylosis is formed the progress of the disease is arrested.

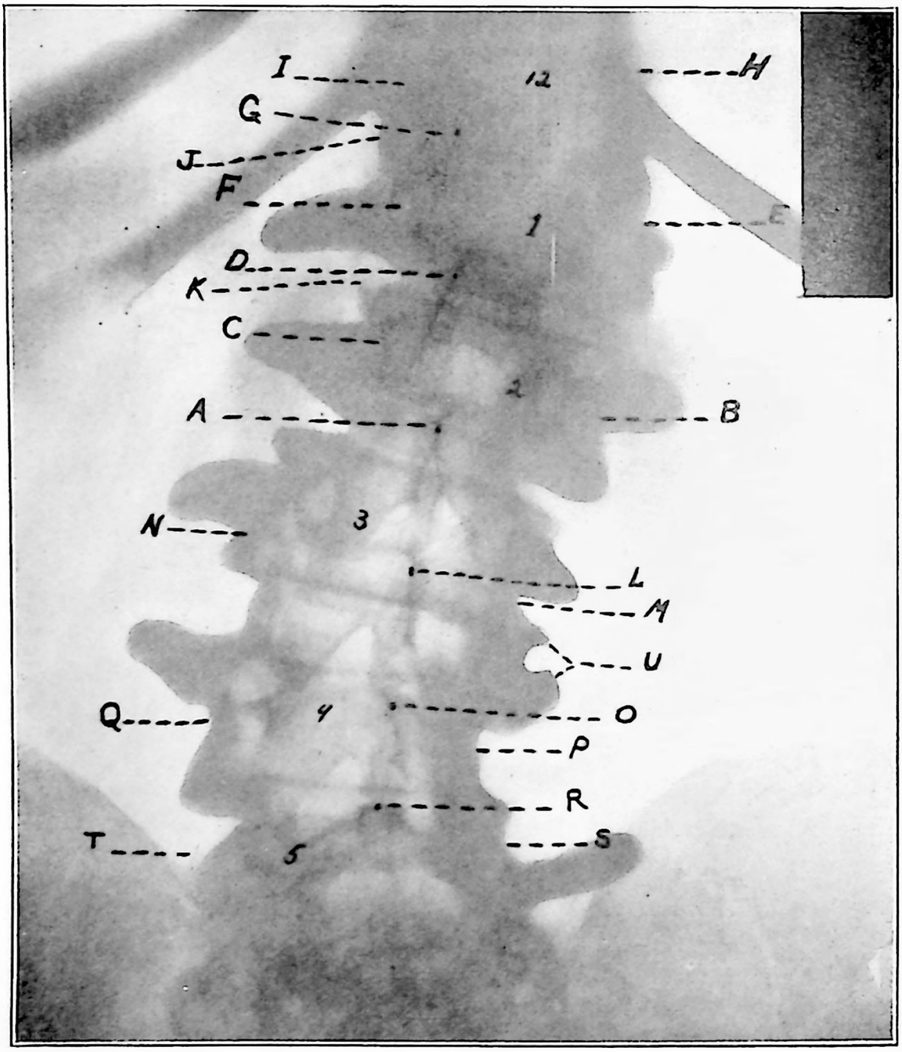


Figure 55

IN READING FIG. NO. 55

We refer to Rules 4 and 5.

In this plate there is a very exaggerated right rotation of the 12th dorsal and the 1st and 2nd lumbar vertebrae and a left rotation of the 3rd, 4th and 5th lumbar.

A represents the center of ossification of the spinous process of the 2nd lumbar, and B and C represent the right and left edges of the body of this vertebra.

We now measure the distance from A to B and from A to C and we find the distance from A to B nearly twice as great as the distance from A to C. This proves that this vertebra is rotated very badly to the right.

Now we will consider the 1st lumbar. The center of the spinous process is indicated by D, and the letters E and F indicate the right and left edges of the body of this vertebra. By measuring from D and E and from D to F we find that this vertebra is also badly rotated to the right. Next we will measure the 12th dorsal, the center of the spinous process of which is designated by G, and the right and left edges of the body by H and I. Upon measurement, we find the 12th dorsal even rotated more to the right than the 1st and 2nd lumbar. You will notice by comparing the center of the spinous processes of the 12th dorsal and 1st and 2nd lumbar as indicated by A, D. and G, that G is considerably to the left of D and A; this would give great impingement between the 12th dorsal and 1st lumbar.

J indicates an ankylosis of the 12th dorsal and 1st lumbar vertebræ.

K indicates exostotic growths on the left inferior edge of the 1st lumbar and on the left superior edge of the 2nd lumbar vertebra, unless adjustments are given to correct the subluxations in this case, an ankylosis of the 1st and 2nd lumbar vertebræ will be formed by these exostotic growths indicated by K.

We will now consider the 3rd, 4th and 5th lumbar vertebræ which form the left rotation. L represents the center of the spinous process of the 3rd lumbar, and M and N indicate the right and left edges of the body of this vertebra. Now compare the distance from L to M and from L to N and we find L much nearer to M and farther from N.

Now we will compare the 2nd and 3rd lumbar and we find that the 2nd lumbar is rotated badly to the right, and the 3rd lumbar is rotated just as much in the opposite direction or to the left. Imagine the extreme pressure that is exerted on the nerves emitting from the intervertebral foramen formed by these two vertebræ.

O indicates the center of the spinous process of the 4th lumbar and P and Q the right and left edges of the body of the 4th lumbar. We measure from O to P and from O to Q and we find this vertebra also rotated to the left.

R represents the center of the spinous of the 5th lumbar, and S and T the right and left edges of this vertebra. Upon measuring this vertebra we find it also rotated to the left, as R is nearer to S and farther from T.

U indicates exostosis forming between the 3rd and 4th lumbar. If this case is not properly adjusted Innate will no doubt continue to build up this exostosis until the vertebrae are solidly ankylosed.

Notice how Innate Intelligence always selects the side of the concavity to build up an ankylosis. Less material and time are required to form an ankylosis on the side of the concavity then would be needed on the side of the convexity.

RULES AND READING FOR FIGURE No. 56

Rule No. 4 applies to this region of the spine.

Letter A represents the center of the spinous process of the 3rd lumbar vertebra, letters B and C indicate the right and left edges of the body of the 3rd lumbar vertebra.

Upon measuring from A to B and from A to C we find that the distance from A to C is much shorter than the distance from A to B, which shows that the spinous process of this vertebra is to the left of the center of the body of the vertebra itself.

Now by comparing A which represents the spinous process of the 3rd lumbar vertebra with D and F which indicate the spinous processes of the 2nd and 4th lumbar vertebræ, we find that the spinous of the 3rd lumbar is considerably to the left of the spinous processes of the vertebra above and below as well as being left of its own body.

Letter D represents the center of the spinous process of the 4th lumbar and E indicates the tip of the spinous of the same vertebra. With the tip of the spinous E bent to the right of the center D our listing of this would be spinous of 4th lumbar bent right.

Now we will consider the 5th lumbar vertebra. G represents the center of the spinous of this vertebra and H and

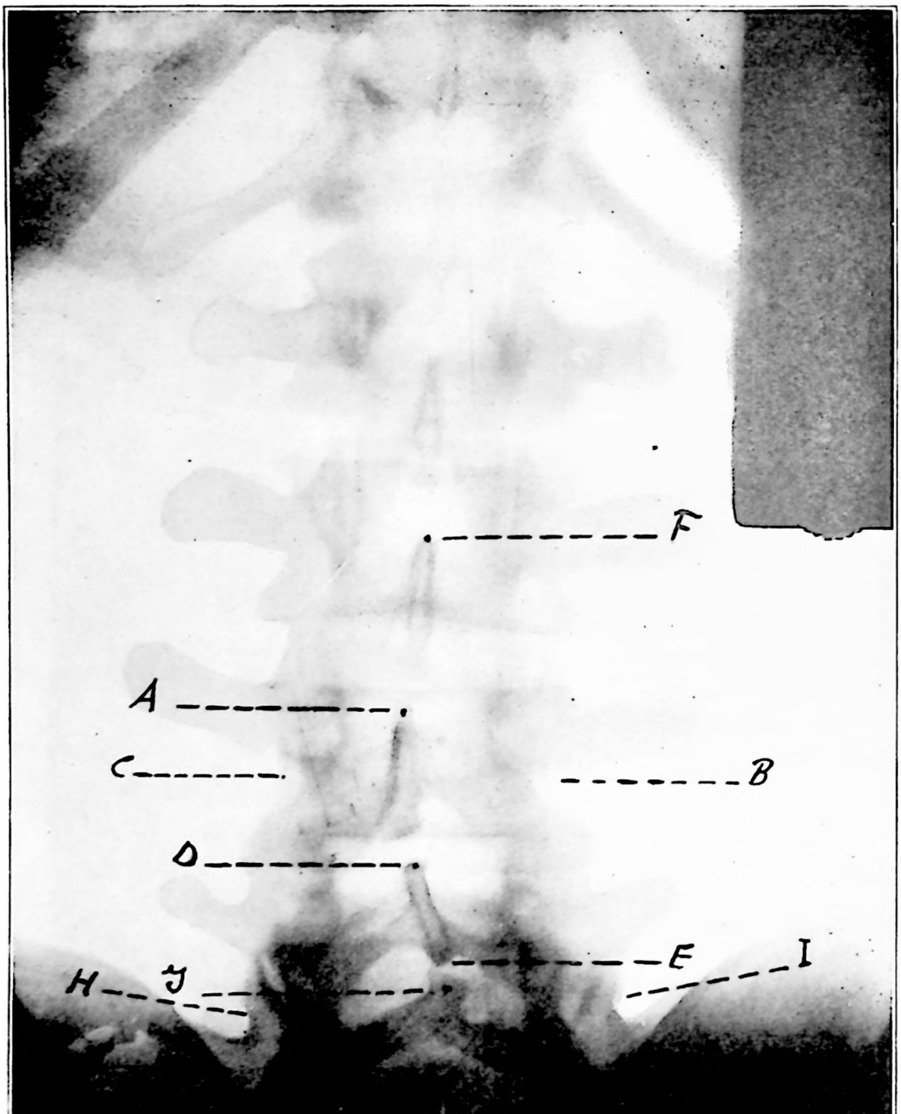


Figure 56

I represent the left and right edges of the body of the same vertebra; now by measuring from G to H and from G to I we find the distance from G to I is shorter than the distance from G to H, so we decide that the center of the spinous G is to the right of the center of the body of the vertebra itself, and by further comparing the center of the spinous of the 5th lumbar with the 2nd and 4th we find the 5th to the right of them as well as to the left of itself.

Our listing of this plate would be:

3rd lumbar	Left
4th lumbar	Bent right
5th lumbar	Right.

Upon careful examination of the transverse process of the 3rd lumbar we find the left transverse has grown superior and the right transverse projects straight out, these points must be taken into consideration when determining superiority and inferiority according to rule No. 6.

FOR READING FIGURE No. 57

Rule No. 5 applies.

In this plate we have a left rotatory scoliosis which is so listed after taking into consideration the following measurements.

First we measure from the center of the spinous processes, which are indicated by AA, A and I, to the right and left edges of the bodies of the vertebra to which these spinous processes belong and we find the spinous processes much nearer the right edges of the bodies than to the left, so we list it as a left rotation of the vertebra. Now by com-

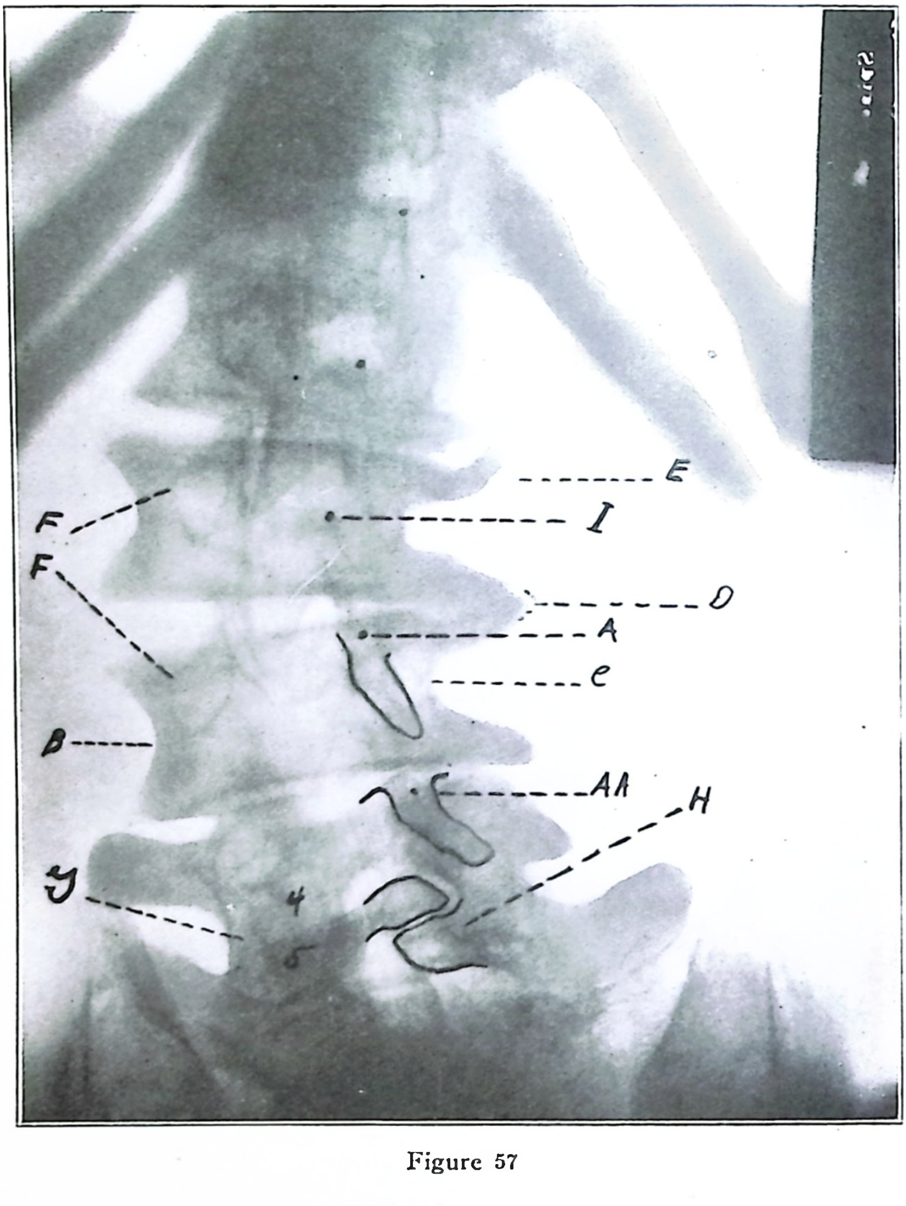


Figure 57

paring the spinous processes and the edges of the bodies with an imaginary median line we find the spinous processes and bodies of the vertebra all to the left of this median line; this is just another fact which proves the left rotation or left rotatory scoliosis. Still another point to consider is the fact that the left articulating processes indicated by the letters F show very plainly, due to the fact that the bodies are rotated to the left and this throws the left articulating processes nearer to the film, the right articulating processes are rotated to the anterior and do not show at all on the film.

A represents the center of the spinous process of the 3rd lumbar and B and C show the edges of the body of this vertebra; now we measure from A to B and from A to C and we find A very near to C and a long distance from B. You will also notice that the spinous process of the 3rd lumbar is rotated nearer to the right edge of its body than the spinous processes of the vertebra above and below are to their respective bodies, therefore, we decide that the 3rd lumbar is subluxated right. Now we will consider AA which indicates the center of the spinous process of the 4th lumbar and we find it to be right of the 3rd and 5th so it also would be listed as a right subluxation.

Letters G and H indicate the laminæ of the 5th lumbar, they have failed to unite and form the spinous process of this vertebra so it will be listed as a cleft spinous process. Letters D and E indicate an exostotic growth between the 1st and 2nd and 2nd and 3rd lumbar vertebræ. This exostosis will soon unite and ankylose these vertebræ unless adjustments are given to correct these subluxations.

Our listing of this plate would be:

A left rotatory scoliosis from 11th dorsal to 5th lumbar inclusive.

2nd lumbar is apex of the rotation.
3rd lumbar subluxated right.
4th lumbar subluxated right.
5th lumbar cleft spinous.

Ankylosis forming between 1st and 2nd and 2nd and 3rd lumbar. Whenever an ankylosis is formed in a rotation you will find that Innate always builds this on the side of the concavity as less time and material are required to ankylose this side than would be required on the side of the convexity.

RULES AND READING OF FIG. No. 58

Figure 58 is a view of the axis, atlas and 3rd cervical vertebræ. Rule No. 8.

Letter A represents spinous process or center of the bifurcation of the axis; B and C the outer edges of the body of the axis. Comparing the center of the spinous process A with the center of the odontoid process D, we find that A is to the left of D, while in the normal they should be in alignment; measuring the distance from A to B we find that A is nearer C and farther away from B, proving that the spinous process is to the left of the median line of the vertebra itself. Our laterality of the axis would be listed as left. Comparing B with C we find that C is much lower than B, making this axis inferior on the left side; adding this inferiority to the laterality would make it a left and inferior subluxation.

Letter E represents the outer lower edge of the right lateral mass of the atlas; F, the left lateral mass of the atlas. Comparing E with B we find it to the right of B; comparing F with C, we find it also is to the right of C. After making this comparison we then take into consideration the spaces found between the odontoid process and the inner margin of the lateral mass of the atlas, showing that the space on the right of the odontoid process is much greater than that on the left. Bear in mind that the axis is tipped inferior on the left and the odontoid process D is tilted slightly left also. This condition would help to make the space greater on the right side of the odontoid process if this atlas were normal.

Figure 58

Letters G and H represent the transverse processes of the atlas; I and J the rami of the jaw. First measure the width of I comparing it with the width of J. If found to be of equal distance, measure from E to the inner or outer edge of I, comparing the findings with F to the inner or outer edges of J.

Drawing a line from either E to F or G to H, we find that the atlas is higher on the right side than on the left. Adding this to our laterality we would have a right superior subluxation of the atlas.

Our spinographic listing would be as follows:

Atlas R S
Axis L I.

RULES AND READING FOR FIG. No. 59

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of the spinous process and B the center of bifurcation of the spinous process of the Axis.

Letters C and D represent the outer upper edges of the axis.

Measuring the distance from either A or B to C and D, it is found that A and B are nearer D and farther away from C; also that A and B are to the right of the center of the odontoid process E, proving that our laterality of the axis is to the right.

Comparing the upper margin of D with the upper margin of C we find that D is higher or superior to C, showing that the axis is also superior upon the right side.

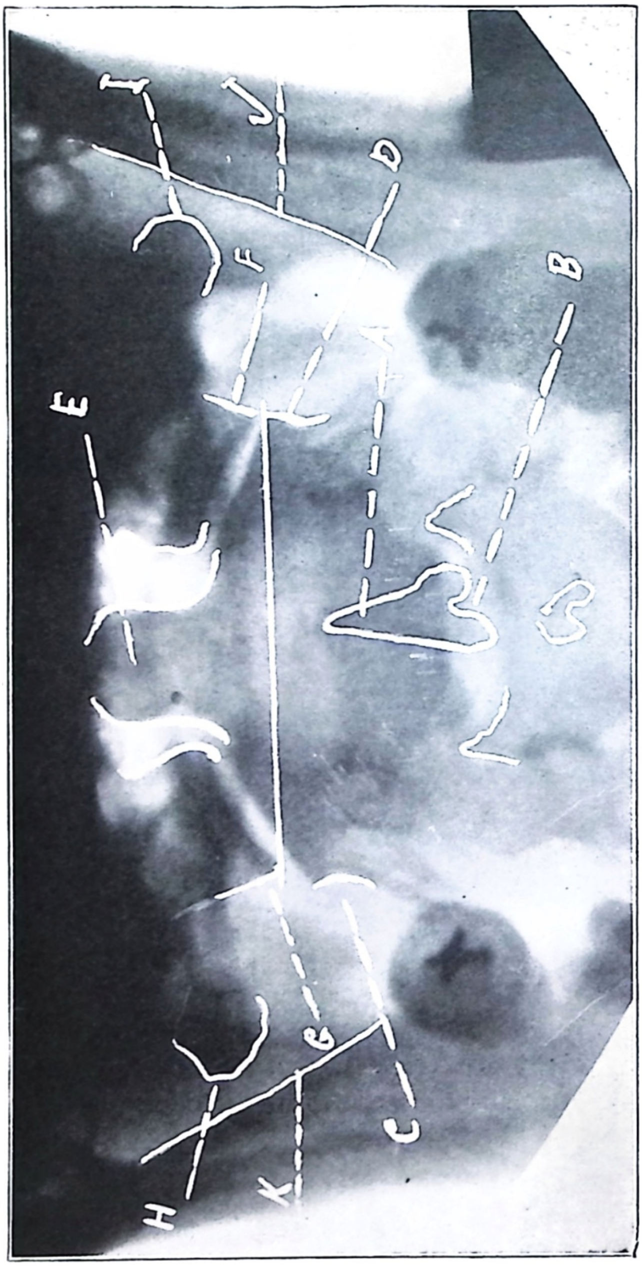


Figure 59

Letter F represents the outer of the lower edge of the right lateral mass of the axis; G the outer lower margin of the left lateral mass of the atlas.

Comparing G with C we find that C is to the left of G due to the fact that the body of the axis is rotated to the left of G.

H and I represent the transverse process of the atlas; J and K represent the rami of the jaw.

Using the measurements from F to J; comparing the findings from G to K with all other points considered, it is found that the atlas is practically normal in respect to laterality. Also that the space between the odontoid process and inner margin of the right lateral mass is greater than the space found upon the left, due to the fact that as the axis has tilted right and superior it has thrown the odontoid process to the left or away from the right lateral mass of the atlas, thereby causing this space to be greater.

Comparing F with G we find that F is tipped higher or superior to G. This tipping of the atlas is adaptative to the subluxation of the axis.

Our spinographic listing would be as follows:

Axis R S.

RULES AND READING FOR FIG. No. 60

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of the spinous process, or bifurcation of the axis; letters B and C the outer upper edges of the axis.

Measuring the distance from A to B and from A to C, we find that A is nearer to C and farther away from B,

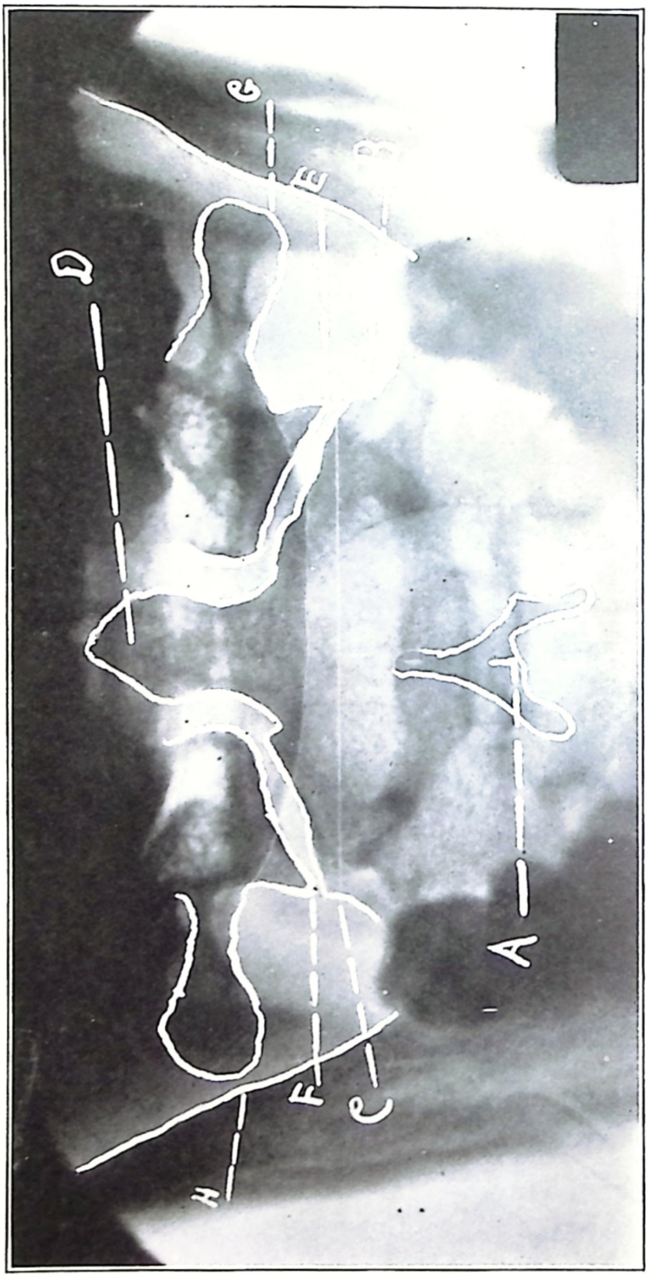


Figure 60

showing that the laterality of the spinous process is to the left. Letter D being the center of the odontoid process we find that A is to the left of it.

Letter E represents the outer lower edge of the right lateral mass of the atlas. Letter F represents the outer lower edge of the left lateral mass of the atlas.

Comparing E with B we find them in alignment; comparing F with C we also find them in alignment. Measuring the distance from E to the inner or outer edge of the rami of the jaw and comparing our findings with the distance from F to the inner or outer edge of the rami of the jaw, we find them equal; also we find that the spaces on either side of the odontoid process and the inner margin of the lateral masses are equal, proving that there is no laterality to the atlas.

G and H represent the transverse processes of the atlas, showing that H and F are slightly superior to G and E. This slight tilting is being produced adaptatively to the subluxation of the axis, as C is a trifle higher than B, making the axis slightly superior on the left side. Notice the long prong upon the right side of the bifurcation of the axis, which under palpation might be misleading.

Our spinographic listing would be as follows:

Axis L, with slight superiority.

RULES AND READING FOR FIG. 61

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents center of spinous process or bifurcation of the axis; letters B and C the outer upper edges of the body of the axis.

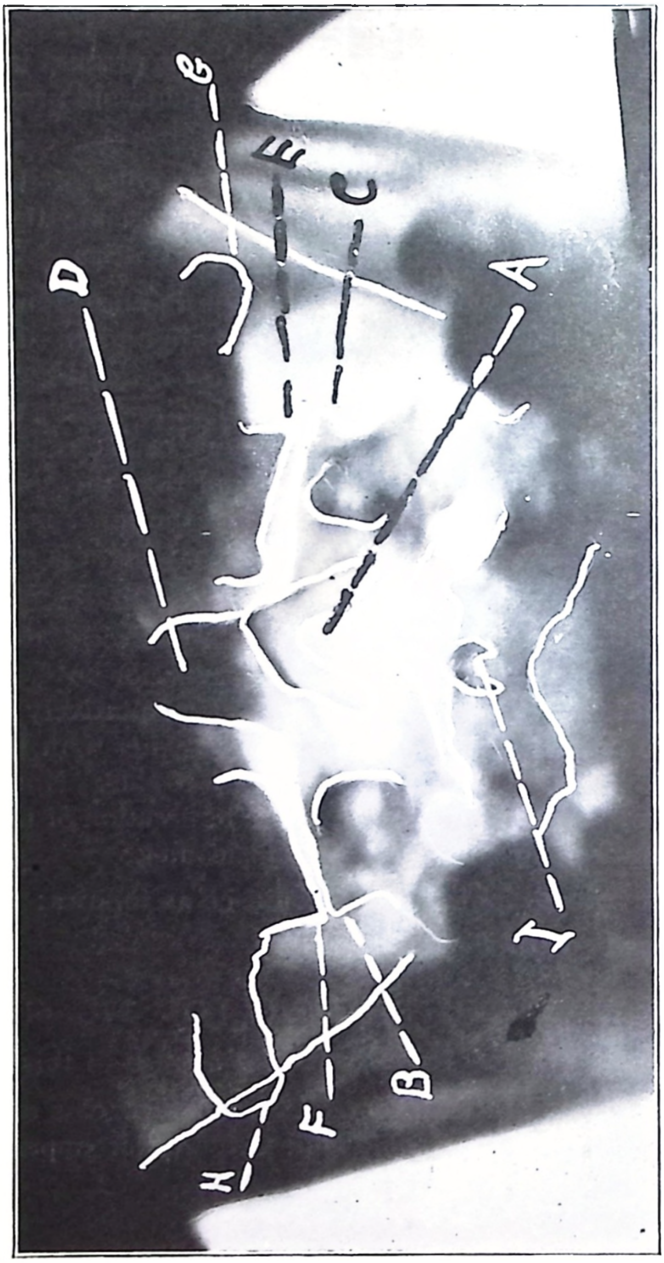


Figure 61

Measuring the distance from A to B and A to C we find that A is nearer to C and farther away from B, showing that our laterality of the spinous process is to the right. Letter D representing the center of the odontoid process, we find that A is also to the right of it.

Comparing B with C we find that C is higher or superior to B, making it superior upon the right side, so that our listing would be RS on the axis.

Letter E represents the outer lower edge of the right lateral mass of the atlas; letter F representing the outer lower edge of the left lateral mass of the atlas. Comparing E with C we find that E is to the left of C. Comparing F with B we find that it is to the left of B, showing that our lateral masses of the atlas are to the left of the body of the axis. Comparing the spaces found on either side of the odontoid process, we find the space on the left is greater than found upon the right, even though our odontoid process D is tilted to the left. Measuring the distance from E to the inner or outer edge of the rami of the jaw and comparing our findings with the distance from F to the inner or outer rami of the jaw, we will find that the left lateral mass of the atlas is nearer the left rami of the jaw, and farther away from the right.

Having considered all other points for laterality we would list the laterality of the atlas as being left.

Letters G and H represent the transverse process of the atlas.

Comparing H and F with G and E, we find that H and F are lower and inferior to G and E, adding to our laterality inferiority of the atlas.

Letter I represents the center of the bifurcation of the 3rd cervical vertebra, showing how small this spinous process is in comparison with the spinous process of the axis.

Our spinographic listing would be as follows:

Atlas L I.

Axis R S.

RULES AND READING FOR FIG. No. 62

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of the spinous process of bifurcation of the axis; letters B and C the outer upper edges of the body of the axis.

Measuring the distance from A to B and A to C we find that the laterality of the spinous process is slightly to the right; comparing B with C we find that C is superior to B.

Letter D represents the center of the odontoid process.

Comparing A with D we find that A is also to the right of D; our listing would then be axis R S.

Letter E represents the outer lower edge of the right lateral mass of the atlas; letter F represents the outer lower edge of the left lateral mass. Comparing E with C we find them in alignment. Comparing F with B we find that B is left of F, which is due to the fact that the body of the axis is rotated on this side, comparing the spaces found on either side of the odontoid process they appear to be normal. Measuring the distance from E to the inner or outer edge of the rami of the jaw, we find them equal. Thus proving, with all other points being considered to determine laterality of the atlas, that there is no laterality of this atlas.

Letters H and G represent the transverse processes of the atlas.

Comparing H and F with G and E we find that G and E are tipped superior to H and F, but notice that the spaces on either side of the odontoid process and lateral masses,

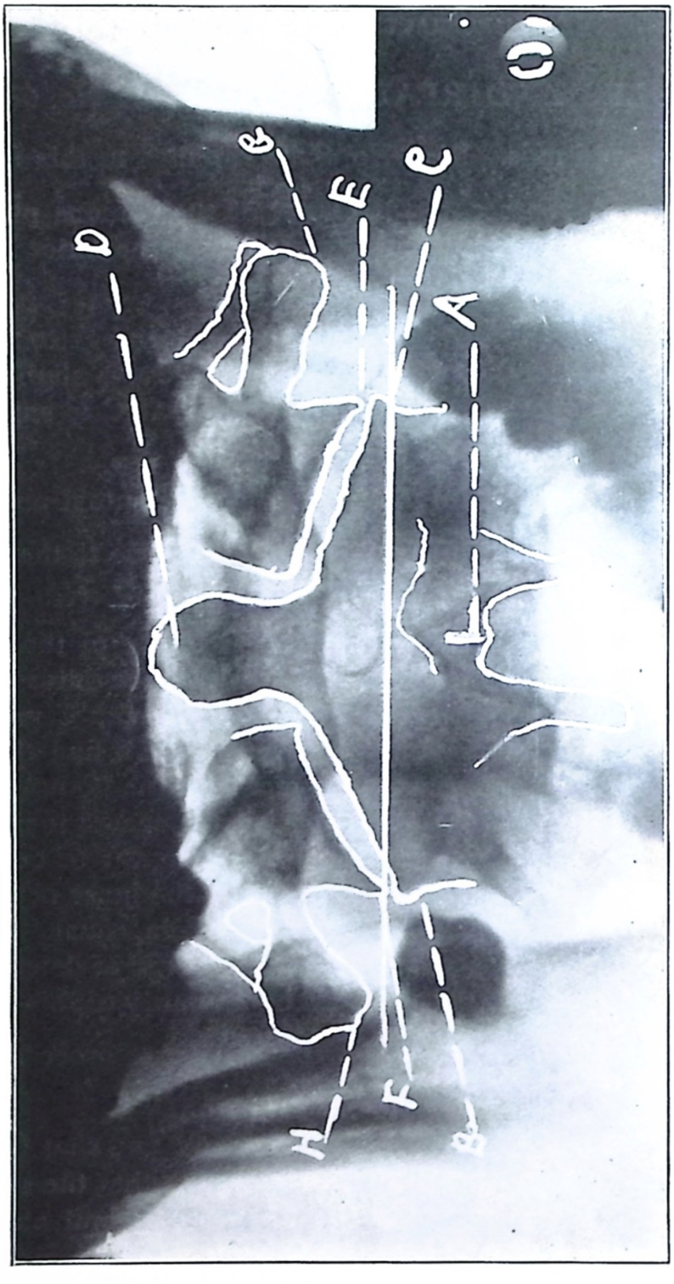


Figure 62

and the articulating spaces between the lateral masses and the body of the axis have not changed. This shows that the tipping of the lateral masses is adaptative to the tipping of the axis. Also compare the left transverse process H with the right transverse process G; carefully note their difference in shape and angle which they assume away from the lateral masses.

You will find therein that the left transverse process H is thicker and is bent inferior, illustrating the fact that it is possible to have bent transverse processes upon the atlas as well as bent spinous processes of other vertebræ which are very misleading in palpation.

Our spinographic listing would be as follows:

Axis R S, with a bent transverse process inferiorly on the left of the atlas.

RULES AND READING FOR FIG. No. 63

Also covered by Rule No. 8.

Reading lateral views of the cervical vertebræ.

Lateral views of the cervical vertebræ are taken for the purpose of determining the following conditions; posteriority and anteriority, superiority and inferiority; dislocations, fractures, exostoses and ankyloses. The reason that these conditions are shown more plainly in a view of this kind than in an anterior-posterior view is that the shadows of the lower maxillary and teeth do not interfere.

Letter A represents the spinous process of the 4th cervical vertebra, which is found to be anterior to the spinous process above it and the one below it. Letter B

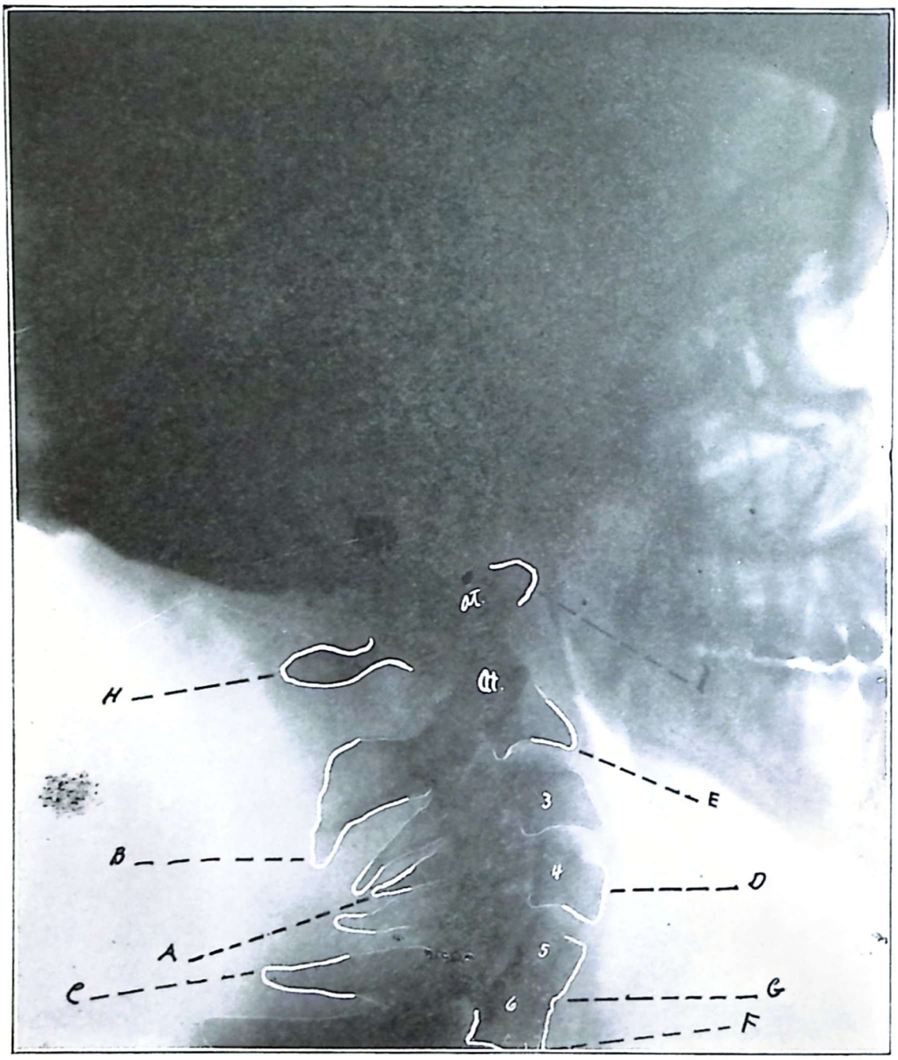


Figure 63

represents the spinous process of the axis showing how much longer it is than the spinous process of the 3rd, 4th and 5th cervical vertebræ. Letter C represents the spinous process of the 6th cervical vertebra showing that it is longer also.

Letter F represents the anterior, inferior edge of the body of the 6th cervical vertebra. Comparing C with F we find that C is superior to F and would be listed as PS.

Letter D represents the anterior edge of the 4th cervical vertebra. Comparing it with the one above and below, we find that it is anterior.

Letter E represents the anterior and inferior edge of the body of the axis. Comparing B with E we find it inferior to E, making our listing here posterior and inferior, or PI.

Letter H represents the posterior ring of the atlas.

Letter I represents the anterior ring of the atlas. Comparing H with I we find that H is inferior to I, while normally they should be practically level. The same is true of B and E.

Letter G represents the intervertebral disc between the 5th and 6th cervical vertebra, showing that it has been absorbed and that ankylosis has taken place between the bodies of these two vertebræ.

Our spinographic listing would be as follows:

Axis PI.

Sixth cervical PS, with ankylosis between the bodies of the 5th and 6th cervical vertebræ, and a lordosis in the middle cervical vertebræ.

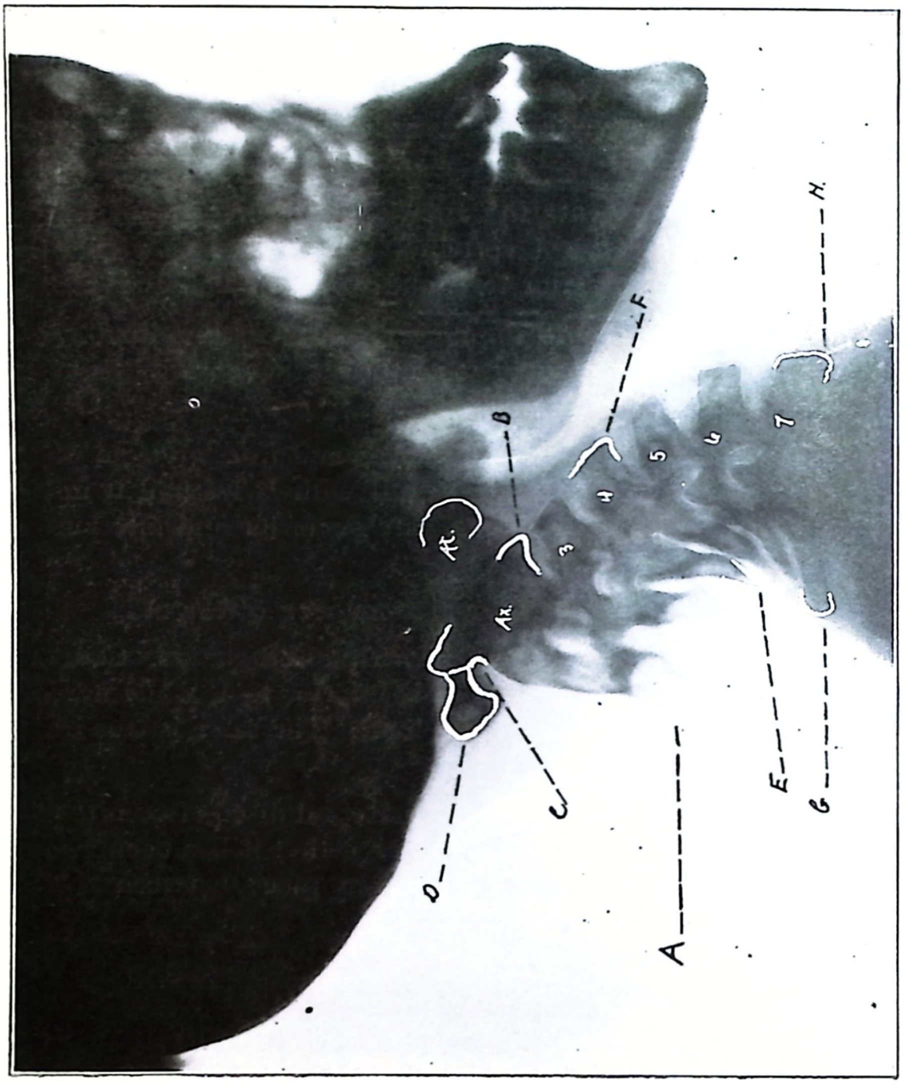


Figure 64

RULES AND READING FOR FIG. No. 64

Are also covered by Rule No. 8.

Reading lateral views of cervical vertebræ.

Figure 64 presents a case of cord pressure between atlas and axis, letter A representing the spinous process of the axis; letter B the anterior and inferior edge of the body of the axis; letter C represents the odontoid process of the axis; letter D the posterior ring of the atlas.

Comparing the angle from A to B we find that A is very much inferior to B, with the odontoid process C tilted backward into the posterior ring of the atlas D, producing pressure on the spinal cord.

Letter E represents the spinous process of the 4th cervical vertebra; letter F the inferior and anterior edge of the body of the 4th cervical vertebra. Comparing the angle from E to F we find that E is also inferior to F.

Letter G represents the spinous process of the 7th cervical vertebra; letter H the inferior and anterior edge of the 7th cervical vertebra. Comparing the angle from G to H we find that G is superior to H.

Our spinographic listing would be as follows:

Axis PI, badly.

Seventh cervical PS.

> While the inferiority of the 4th cervical vertebra is adaptative to the acute posteriority and inferiority of the axis.

Figure 65

RULES AND READING OF FIG. No. 65

Also covered by Rule No. 8.

Reading lateral views of cervical vertebræ.

Figure 65 presents a case of cord pressure at the 4th cervical vertebra.

Letter A represents the spinous process of the 4th cervical vertebra; letter B the anterior edge of the body of the 4th cervical vertebra; letter C represents the articulating process of the 4th cervical vertebra showing how this articulating process has slipped posterior to the one above it. Comparing the anterior edge of the body B, with the anterior edge of the bodies of the one above and below, it shows that it is also posterior, practically making a dislocation of the 4th cervical vertebra which, in the medical field would be classed as a broken neck.

In the Chiropractic field this case was restored to normal articulation and health by Chiropractic adjustments.

Letter D represents the spinous process of the 6th cervical vertebra; letter E represents the anterior edge of its body. Comparing the angle from D to E we find that D is inferior to E.

Letter F represents the posterior ring of the atlas which is tipped superior and very close to the occiput, this condition being adaptative to the kyphosis produced in the middle cervical vertebræ.

Our spinographic listing would be as follows:

4th cervical P, very much.
6th cervical PI.

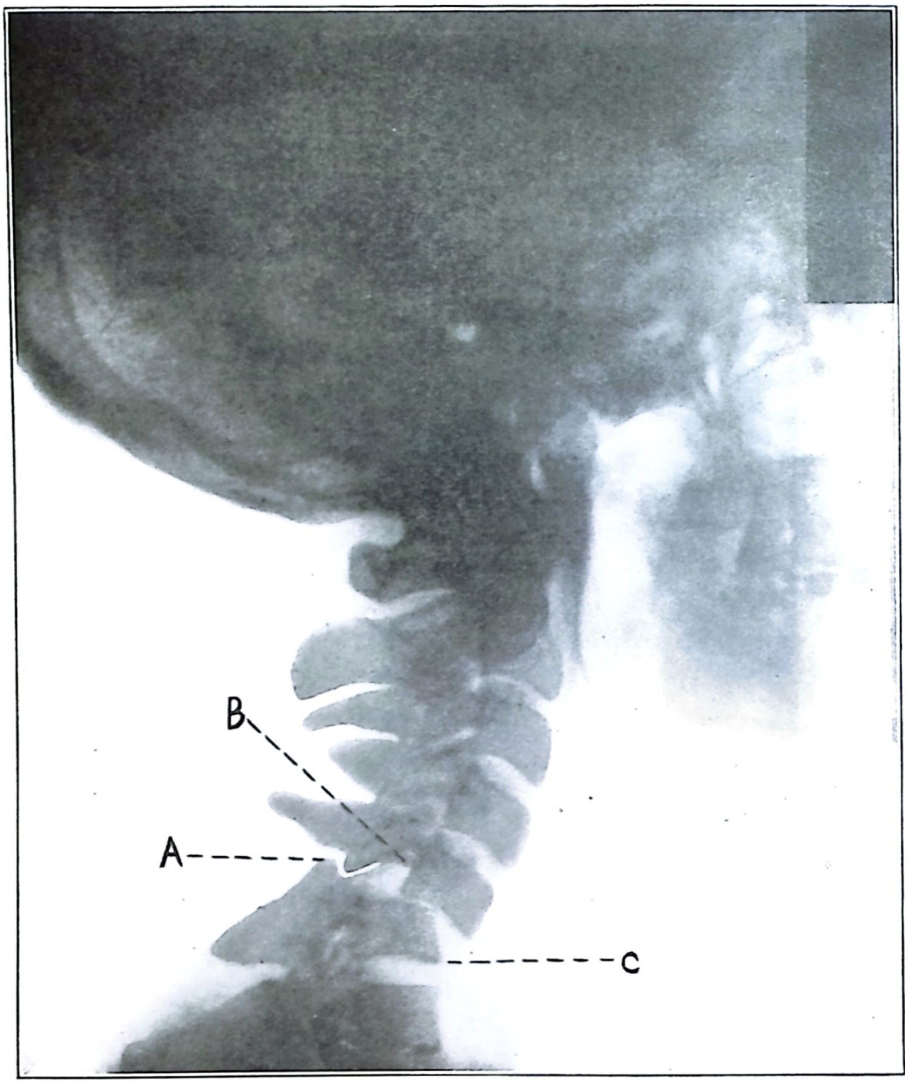


Figure 66

RULES AND READINGS OF FIG. No. 66

Figure No. 66 is a lateral view of the cervical region showing a dislocation of the 6th cervical vertebra which occurred when the patient struck his head on something in a pond in which he was diving.

Letter A indicates the superior articulating process of the 6th cervical vertebra. Normally this superior articulating process should be anterior to B, which indicates the inferior articulating process of the 5th cervical.

In this plate it can be seen that the superior articulating process of the 6th cervical as indicated by A has been thrown out of its normal articulation with the inferior articulating process of the 5th cervical vertebra, that it is posterior to B, which indicates the inferior articulation of the 5th cervical, and it is locked in this position by the articulating process B, being thrown anterior or in front of the articulating process A.

Letter E represents the anterior inferior edge of the body of the 6th cervical.

Notice that the anterior superior edge of the body of the 6th cervical is approximately in the center of the body of the 5th cervical.

In order to make it possible for the 6th cervical to assume its normal position, it will be necessary to adjust the 5th cervical straight to the superior far enough to allow the superior articulating process A to slip back in front of B.

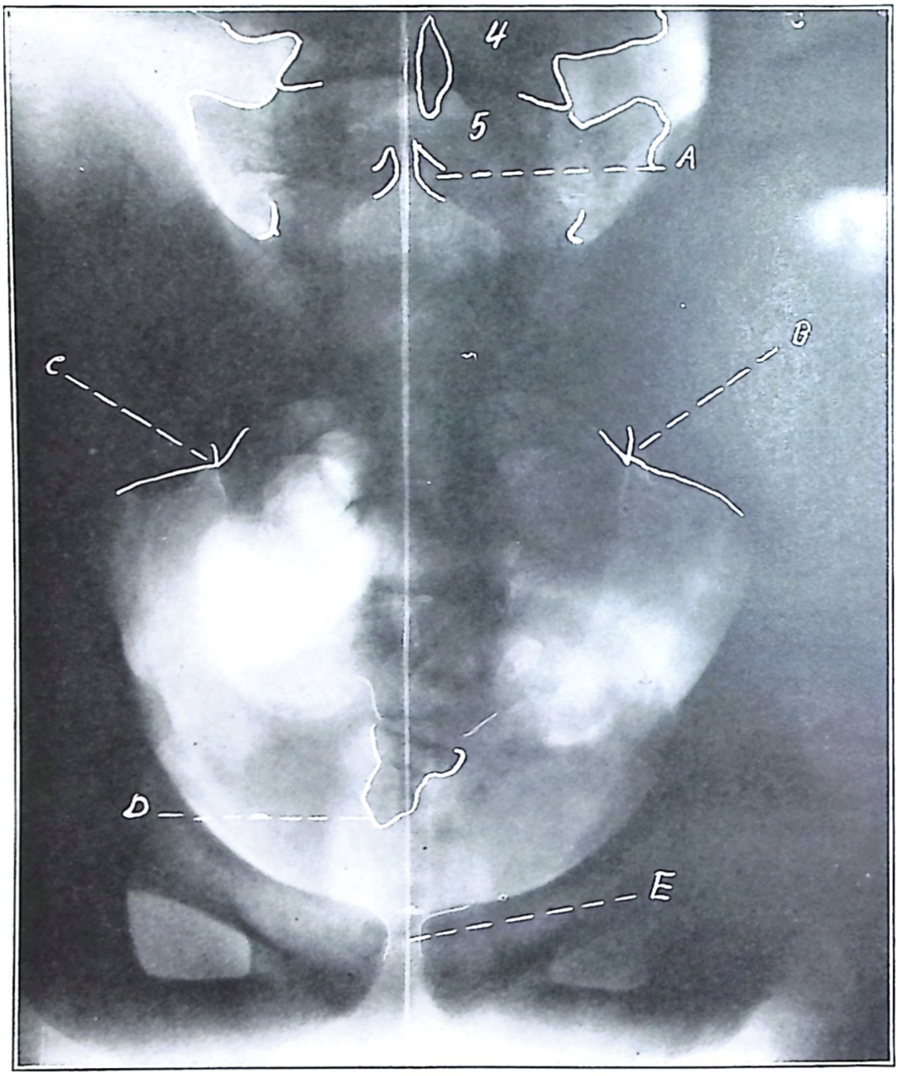


Figure 67

RULES AND READING FOR FIG. No. 67

Rules Nos. 9 and 10.

To determine sacro-iliac and coccyx subluxations.

Letter A represents the right side of the spinous process of the 5th lumbar vertebra, showing that it has never united with the left side to form a complete spinous process. This condition would be listed as a cleft spine.

Letters B and C represent the lower border of the articulations of the sacrum and ilii on either side. It is from these borders that we determine whether or not the ilii are subluxated superior to their articulation with the sacrum.

Letter D represents the tip of the coccyx, which is found to be subluxated to the left of E, which is the center of the pubic articulation. Also notice that the spinous process of the 4th lumbar vertebra is to the right of the spinous process of the 5th lumbar vertebra. Upon measurement we would find that the 5th lumbar vertebra is subluxation to the left and superior.

Our spinographic listing would be as follows:

5th lumbar, LS with a cleft spinous process.

Coccyx, L.

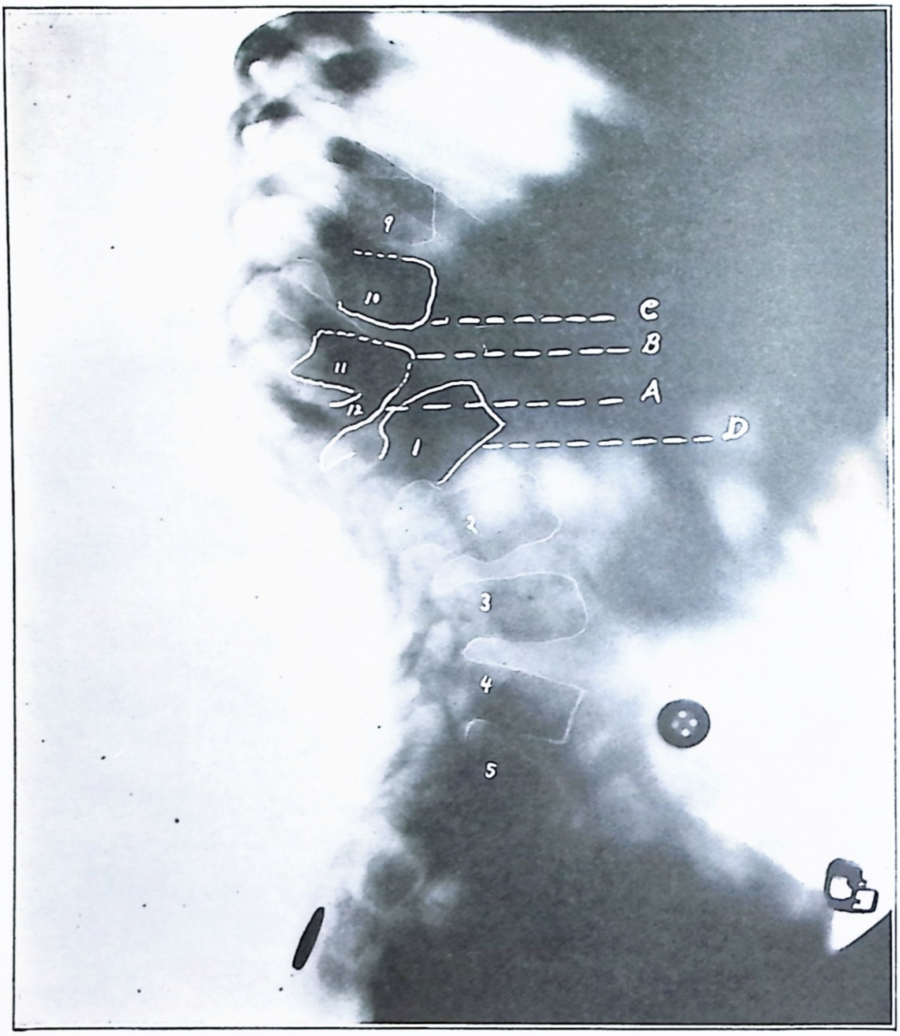


Figure 68

RULES AND READING FOR FIG. No. 68

This plate presents a lateral view of the lower dorsal and lumbar region. Rule No. 11 also applies to this plate.

Letter A represents what is left of the anterior edge of the body of the 12th dorsal vertebra; letter B represents the anterior edge of the body of the 11th dorsal vertebra; letter C represents the anterior edge of the body of the 10th dorsal vertebra; letter D represents the anterior and inferior edge of the first lumbar vertebra.

Comparing A with B and C we find that A is very much posterior to B and C. Comparing A and D we find that A is much more superior to D than either B or C; also that the body of the 12th dorsal vertebra A, is much thinner or more wedge-shaped than either B or D; also, that it is ankylosed anteriorly to the body of the 11th dorsal vertebra, D, thus producing an acute kyphosis of the 11th and 12th dorsal vertebra and a lordosis of the lumbar vertebra. This is a condition of Pott's Disease or caries of the 12th dorsal vertebra. The ankylosis of the 11th and 12th dorsal vertebra is adaptative, in the fact that it is to help strengthen this weakened link. Lateral views should be taken of all cases where suspected conditions of Pott's Disease or caries are thought to exist.

CONCLUSION.

In conclusion, I wish to impress upon the student or practitioner that in studying this text, or taking the course as taught by this institution, that it is our aim to give the student a foundation of Chiropractic spinography, which he can improve upon only by experience.

After all that has been written upon the subject of Roentgenology, there is still more that could be written, as the possibilities of the X-Ray are far-reaching, and unknown today, as every year sees improvement and development of this great work.

Therefore, it is the hope of the author that this text will be of assistance to every one who reads it and that they will become a student of this work, not only today, but tomorrow and every other day. Who knows but what you may develop some unknown X-Ray technic?

It is to be expected that you may spoil plates when commencing to use spinography in your practice, which will teach you your weak points so that your next exposure may be improved upon. Experience is the best teacher after all.

If this work has been beneficial to the Chiropractic field as it is intended for, even though there are some who do not use it in their practice, it will have served its purpose.

THE END.

INDEX